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## This Month—

### Front Cover

"Liberty in a new light." The new floodlighting installation for New York Harbor's famous Statue of Liberty provides an intensity of 30 footcandles for the statue itself and 15 footcandles for the base. This is accomplished by 96 1,000-watt projectors in the star-shaped parapet around the base and many smaller units at other parts of the statue; the torch is lighted by fourteen 1,000- and six 100-watt units.

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NOMINATIONS for A.I.E.E. 1932-3 national officers are announced, with brief biographical sketches of the nominees. *p. 52-55*

THREE-POWER electric locomotives are designed especially for use on portions of track not completely electrified. *p. 9-13*

STEAM or electric power station auxiliaries? Both sides of the argument are presented under sponsorship of the Institute's power generation committee. *p. 20-28*

MANY important advances in dielectric research were revealed at the fourth annual meeting of the committee on electrical insulation, National Research Council. *p. 30-35*

GREATER standardization in sizes and ratings of manufactured products, together with the increased application of "preferred numbers" should result in economies for both consumer and producer. *p. 14-19*

WINTER convention for 1932 soon will be here; features scheduled include "fourteen technical sessions, a variety of inspection trips and social functions, and a special program for women guests." *p. 50-51.* Most of the papers to be presented are abstracted in this issue. *p. 39-49*

CORRECTION—In "III—Insulation Material Aids Extinction of Cable Arcs" appearing in ELECTRICAL ENGINEERING for December 1931, the third from the last sentence in column one, p. 956, should have stated "In those tests where the insulation had been carefully cleaned away about 6 in. or more from the arc, the arc would then persist. In this case the arc voltage was about 100 volts, or between one-third and one-fourth as large as the value of 350 volts found when the arc was bounded closely by insulation."

# Radio Interference from Insulator Corona

**Extended laboratory tests reveal that the corona formation voltage and the initial radio interference voltage of clean, dry insulators are identical. Oscillograms show many interesting characteristics of insulator corona current and of the radio interference caused by it. Means for reducing the interference are suggested.**

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RADIO INTERFERENCE originates on high voltage insulators from two principal causes: (1) from very small ionization or corona discharges due to overstressed air in the dielectric field; and (2) from intermittent leakage currents flowing through conducting deposits of various kinds on the insulating surfaces. Both of these causes of interference are of sufficient importance to warrant investigation. However, because the corona discharge type of interference is universally troublesome, and serious surface leakage is more or less localized in certain geographical areas which are subject to salt fogs or special industrial conditions, this investigation has been devoted to a study of interference due to corona.

The voltage gradient or stress on a dielectric transmitting dielectric flux is directly proportional to the flux density, and inversely proportional to the ease with which the insulating material transmits flux. Therefore when two dielectrics are transmitting the same dielectric flux in series, the dielectric having the lowest permittivity obviously will be subjected to the highest voltage gradient per unit thickness. The insulation of high voltage power lines consists of two dielectrics, air and some other solid insulating material such as porcelain or glass. In their practical application, these gaseous and solid materials are combined in series and parallel arrangements in the dielectric circuit.

Air and solid materials have widely different dielectric characteristics. High voltage insulator porcelain transmits dielectric flux approximately six times as readily as air and has a dielectric strength several times greater. Glass used in modern high voltage insulators has a permittivity four and one-half times that of air, and, like porcelain, also has a dielectric strength several times that of air. Because of the widely different permittivities, exceedingly careful design is necessary to use air and porcelain or air and glass in series combinations with high impressed voltages. Thin air-gaps in series with thick sections of porcelain or glass must be avoided in regions of dense dielectric flux, or failure of the air by ionization will result. This undesirable condition is found in three different places on many of the standard multi-shell pin type insulators as now designed, as follows:

1. At points where the conductor and tie wire are not in intimate contact with insulator head.
2. At the contact between the pin or thimble and the insulating material.
3. Between shells of multi-part insulators.

When insulators so designed are used on high voltage lines, the air in these regions of high voltage gradient fails due to the ionization-by-collision phenomenon. This air failure occurs very suddenly at the time the critical ionizing gradient is reached each half cycle of the alternating voltage impressed on the insulator. Because of the changed energy storage in the capacitance and inductance of the electric circuit the sudden flow of ionizing current resulting from the corona formation sets up oscillations in the electric circuit. The oscillations thus generated cover a wide band of frequencies from the lower range of audibility through the higher radio frequencies. These higher frequency radiations cause radio interference.

Laboratory tests show conclusively that radio interference from clean, high-voltage insulators is caused by corona discharges occurring at locations on the insulator where the air is ionized by excessive dielectric flux concentration. Large numbers of tests conducted in a darkened room showed that corona formation and radio interference always are coincident. To obtain this result, great care must be used in performing the tests. The radio receiving set must have high amplification, the loop antenna must be closely coupled with the circuit radiating the interference, and the corona observations made very carefully in a dark room. Obviously when the corona formation first occurs under a conductor behind a tie wire, or in the pin-hole of an insulator, it cannot be observed. Radio noise will occur coincident with this hidden corona and therefore precedes the first observable appearance of corona. The fact that

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Full text of a paper (No. 32-1) to be presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25-29, 1932.

Table I—Radio Interference and Corona Formation Voltage Data for Pin Insulators

| INSULATOR NUMBER | NOMINAL RATING KV | INITIAL RADIO INTERFERENCE DATA: INSULATOR POTENTIAL KV | LOCATION ON INSULATOR | INSULATOR VISIBLE CORONA DATA: HEAD KV | PIN KV | SHELLS* 1–2 KV | 2–3 KV | 3–4 KV | REMARKS<br>MEAN ATMOSPHERIC CONDITION<br>BAROMETRIC PRESSURE 757.2 MM. OF HG.<br>TEMPERATURE 21.3 DEGREES CENTIGRADE<br>WET BULB TEMPERATURE 55.3 DEGREES FAHRENHEIT<br>DRY BULB TEMPERATURE 70.4 DEGREES FAHRENHEIT<br>RELATIVE HUMIDITY 36 PER CENT |
|---|---|---|---|---|---|---|---|---|---|
| A–4 | 66 | 20.4 | PIN | 20.4 | 18.4 | 30.5 | 25.7 | – | Solder coating in conductor and tie wire grooves. |
| B–5 | 66 | 23.0 | HEAD | 23.0 | 32.7 | 62.2 | 86.6 | – | Silver and Bismuth coating on head. Zinc thimble in pin hole. |
| B–6 | 66 | 23.5 | HEAD & PIN | 23.5 | 23.5 | 67.6 | 75.0 | – | Silver and Bismuth coating on head and in pin hole. |
| D–4 | 66 | 8.1 | HEAD | 8.5 | 52.0 | 53.6 | 42.9 | – | Standard porcelain insulator with ¾ in. malleable thimble. |
| D–5 | 66 | 29.9 | CAP TO PORC. | 30.2 | 37.1 | 50.3 | NOT TAKEN | – | Malleable cap on head ¾ in. malleable thimble, discharge cap to porcelain. |
| D–6 | 66 | 32.1 | CAP TO PORC. | 32.1 | 40.4 | 54.4 | 58.9 | – | Malleable cap on head ¾ in. malleable thimble, discharge cap to porcelain. |
| D–6a | 66 | 42.4 | BETWEEN SHELLS 2&3 | 47.6 | 45.7 | 43.4 | 42.4 | – | Crevices head and thimble filled with Portland Cement. |
| D–6b | 66 | 17.9 | HEAD | 17.9 | 71.5 | 97.1+ | 70.7 | – | Crevices head and thimble filled with Portland Cement, between shells with Pothead Compound. |
| D–7 | 66 | 25.2 | PIN | 27.0 | 25.2 | 46.5 | 51.9 | – | Malleable cap on head ¾ in. malleable thimble, discharge cap to porcelain. |
| D–7a | 66 | 60.7 | HEAD | 60.7 | 86.7 | 53.8 | 56.8 | – | Crevices head and thimble filled with Pothead Compd. Discharge at head. |
| D–7b | 66 | 38.7 | HEAD | 38.7 | 64.1 | 91.6+ | 91.6+ | – | Crevices at head, shells, and thimble filled with Pothead Compound. Discharge over compound at head 45.3 KV. |
| F–4 | 70 | 25.2 | HEAD | 25.5 | 38.3 | 44.7 | 41.1 | 37.4 | Sanded head coated with electrolytic copper ¾ in. malleable thimble. |
| F–5 | 70 | 9.5 | HEAD | 9.5 | ← NOT TAKEN → | | | | Same as F–4. Discharge in fault in metal coating. |
| G–1 | 70 | 12.3 | HEAD | 12.3 | 38.5 | 81.1+ | 81.1+ | – | Standard Insulator. Corona on head at tie and in pin hole around metal. |
| G–2 | 70 | 50.3 | HEAD | 50.3 | 81.1+ | 81.1+ | 81.1+ | – | "Nostatic" coating on head and in pin hole. |
| G–2a | 70 | 40.3 | HEAD | 40.3 | ← NOT TAKEN → | | | – | After 10 A.I.E.E. Std thermal test cycles, 35 impulse flashovers at 450Kv maximum, and five hours heavy conductor and tie wire vibration, corona first formed where impulse arcs destroyed the conducting coating on the head. |
| G–3 | 70 | 59 | HEAD | 59.0 | 80.0+ | 80.0+ | 80.0+ | – | "Nostatic" coating on head and in pin hole. |

*Shells numbered from head to pin.

corona formation and radio interference are coincident was determined by a great many tests using insulators so designed and treated that the first corona occurs in locations easily observed in a darkened room. Some of these test data are shown in Table I.

## Radio Interference and Visual Corona Formation Voltages

At the time the investigation of radio interference was started, it was known that in general the interference from pin type insulators is more pronounced than that from the suspension type; also, that more interference was radiated from high voltage than from low voltage pin type insulators. For these reasons, practically all tests have been confined to pin and pedestal insulators rated at from 66 to 73 kv. The radio interference and visual corona formation voltage tests were made with apparatus connected as shown in Fig. 1. Great care was exercised to avoid extraneous interference from the testing equipment. To prevent interference from minute discharges between metallic parts in close proximity to each other, all pieces of hardware associated with the experimental apparatus were bonded carefully either to the high voltage conductor or to the ground. A polished ½-in. galvanized iron pipe (0.83 in. outside diameter) shielded at each end, was used as the conductor; this pipe was free from corona for all voltages up to 100 kv.

## Tests on Pin Insulators

A few representative determinations of the radio interference and corona formation voltages for pin insulators are given in Table I. The tabulated values show that radio interference and visible corona occur at the same value of insulator voltage except when the corona starts in locations not in view.

The unshielded insulators started radiating interference and showed visible corona at the surprisingly low voltages of from 8.0 to 12.2 kv. to neutral or approximately 25 per cent of the normal operating voltage. However, all of the shielded insulators except F-5 showed a marked improvement in the radio interference formation point, and only one insulator G-2 was free from radio interference at normal operating voltage. The lower case subscript letters (Table I) indicate insulators treated or modified as shown under the remarks in the table.

It may be observed that improvements were effected by sealing all crevices with cement or compound; the radio interference voltage was increased thereby from 32 to 123 per cent.

## Fundamentals of Preventing Insulator Radio Interference

Because of the nature of the disturbing electrical discharges on insulators there are at least three methods of attack to eliminate them. These are to:

1. Design the insulator in such a manner that no regions of overstressed air exist under normal operating conditions.
2. Provide conducting coatings to act as dielectric flux distributors at the head, in the pin-hole, and on other necessary parts.
3. Displace the overstressed air with an insulating compound dielectrically strong enough to withstand the potential.

From at least one standpoint, method 1 is the most desirable of the three because it employs no auxiliary material which may be subject to deterioration in service. This method, however, is the most radical departure from present practise and therefore probably will require a longer development period if found practicable at all. If method 2 employing a dielectric flux distributor is used, the conducting material must be in such intimate contact with the solid dielectric that all air between the conducting coating and the porcelain or glass is excluded. The use of method 3 requires that all air in regions subject to being overstressed to the ionizing point be displaced by an insulating compound.

Some difficulties are encountered in employing any of these three methods. Conducting coatings must remain at all times in intimate contact with the insulator material, and must withstand weathering, electrolysis due to leakage currents, temperature changes, and abrasion due to conductor and tie wire motion. Further such coatings must not terminate in positions that will overstress the air in other parts of the dielectric circuit, and the flashover value of the insulator must not be reduced below the required factor of safety. If insulating compound is used, it must withstand weathering, stay in place through the extremes of temperature to which it may be subjected, and not be displaced by the motion of the conductor and tie wire to the extent of impairing its effectiveness.

Although the design of a satisfactory insulator of practical proportions and which will be suitable for mass production apparently is not a simple problem, it is believed to be entirely possible to meet the requirements outlined and build an insulator entirely free from radio interference at a safe margin above its normal operating voltage.

## INSULATOR CORONA CURRENT INVESTIGATION

The magnitude and character of the corona current of high voltage insulators is of great interest and importance because these characteristics are direct indications of the radio interference radiation produced. Corona current is not easily studied because (1) it is quite small, attaining maximum values of approximately 40 microamperes for normal voltage on a standard 66-kv. insulator; (2) it is obscured by the insulator charging current which is approximately 0.4 milliampere maximum or 10 times the corona current for an insulator of this size; and (3) it has superimposed oscillations of very high frequency.

An instrument suitable for the investigation of currents of these magnitudes and characteristics must have a high sensitivity and be capable of responding faithfully to high frequencies. The device that meets these requirements most satisfactorily is the low voltage cathode ray oscillograph. Because of the low anode-cathode voltage and resulting low velocity of the electron stream, this instrument has the highest sensitivity of all of the cathode ray oscillographs; and the cathode beam diffusion due to the relative immobility of the positive focusing ions is not excessive for beam speeds of $3 \times 10^6$ cm. per sec. on the fluorescent screen.

Although the cathode ray oscillograph is well suited to the study of high frequency discharges, it will not of itself separate the corona current from the charging current. To overcome this difficulty the circuit shown in Fig. 2 was devised to balance out the charging current leaving only the corona current to produce deflection. With this circuit arrangement, it is possible by adjusting $R_1$ and $C_3$ to make the vertical deflecting potential on the oscillograph zero for all insulator voltages up to the critical corona formation voltage. At this critical voltage and for higher voltages, the oscillograph vertical deflecting voltage is proportional to the instantaneous value of the insulator corona current in $R_2$. This condition obtains because $C_1$ is free from corona. A glass insulator with dielectric flux distributing coatings on the head and in the pin-hole, and found by test to be free from corona up to 50 kv., was used for $C_1$ when the accompanying cathode ray oscillograms were taken.

The horizontal deflecting or sweeping voltage for the oscillograph was obtained from a neon oscillator connected as shown in Fig. 2. This type of oscillator produces practically a straight line time axis that can be operated over a wide range of sweeping frequencies by the adjustment of $R_3$ and $C_4$. This sweeping oscillator can be synchronized readily with the frequency producing the phenomena under observation so that a stationary image either for observation or recording photographically is obtained. To eliminate stray dielectric fields a grounded wire cage 5x5x6 ft. high was used to shield all apparatus associated with the oscillograph and neon oscillator.

Voltage was applied to the laboratory line and increased to a value just below the critical corona voltage for the insulator under test. At this voltage,

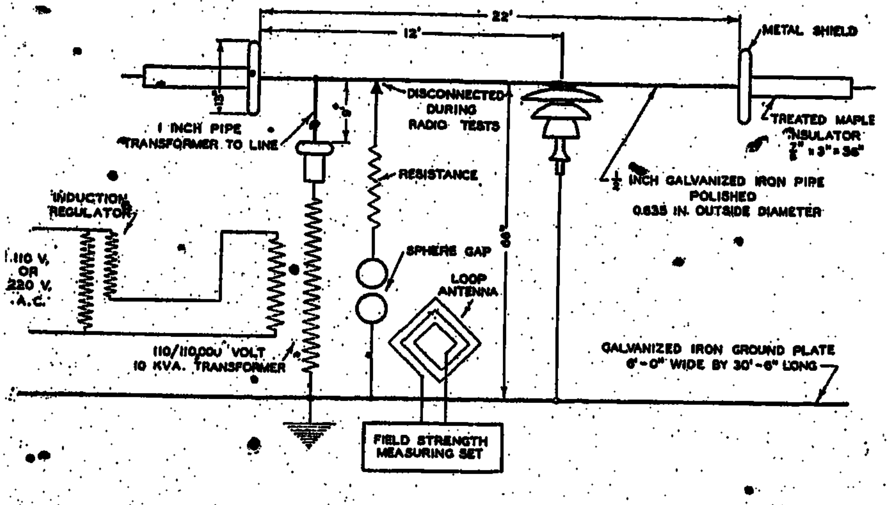
22'
12'
METAL SHIELD
DISCONNECTED DURING RADIO TESTS
1 INCH PIPE TRANSFORMER TO LINE
TREATED MAPLE INSULATOR 7/8" x 3" x 36"
RESISTANCE
1/2 INCH GALVANIZED IRON PIPE POLISHED 0.835 IN. OUTSIDE DIAMETER
INDUCTION REGULATOR
110 V. OR 220 V. A.C.
SPHERE GAP
LOOP ANTENNA
110/110,000 VOLT 10 KVA. TRANSFORMER
GALVANIZED IRON GROUND PLATE 6'-0" WIDE BY 30'-6" LONG
FIELD STRENGTH MEASURING SET

Fig. 1. Schematic diagram of apparatus for laboratory investigation of radio interference and corona formation voltages on pin insulators

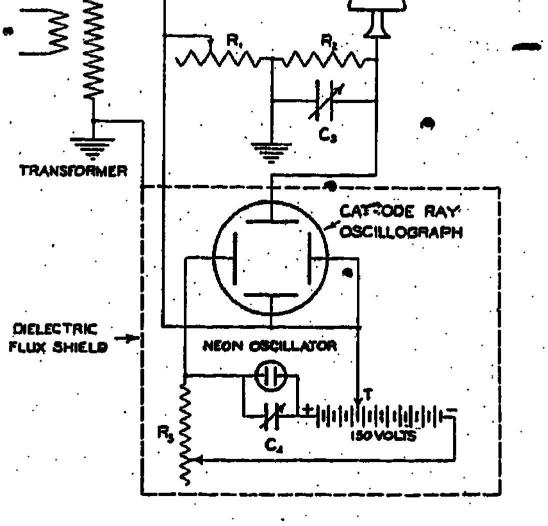

Fig. 2. Circuit for obtaining cathode ray oscillograms of insulator corona current. Note that the insulator charging current is balanced out

resistance $R_1$ and capacitance $C_3$ were adjusted to make the vertical deflecting voltage zero. These adjustments were made while the neon oscillator was sweeping the cathode beam over the time axis, conditions under which any slight inaccuracies in balance were detected readily by the deviation of the beam from a straight line. When this balance was established accurately, a series of corona current oscillograms was taken for the insulator at various conductor to pin voltages from 10 to 40 kv., r.m.s., in increments of 5 kv.

In Fig. 4 is shown a series of corona current oscillograms taken on a standard three-shell 66-kv. porcelain insulator with a ¾-in. malleable thimble cemented in the pin-hole. Oscillogram *G* (40 kv.) shows the normal corona current for this insulator operating on a three-phase transmission line at a line potential of 69.3 kv. Atmospheric conditions were representative and normal, air density being 1.006 and the absolute humidity 9.4 g. per cubic meter.

Oscillograms reproduced in Fig. 5 show that when the ionization gradient is reached, the current rises to a maximum value quite abruptly during the positive half cycle and decays rapidly with considerable oscillation, reaching zero practically coincident with the occurrence of maximum voltage on the insulator. During the negative half cycle the corona current does not reach its maximum value in so short a time interval as in the positive half cycle, the oscillations appear to be much more violent, and the corona current is sustained at a high value for a longer time. The higher sustained value of negative current is shown clearly by the fact that for the same line voltage the area under the negative wave is greater than under the positive wave.

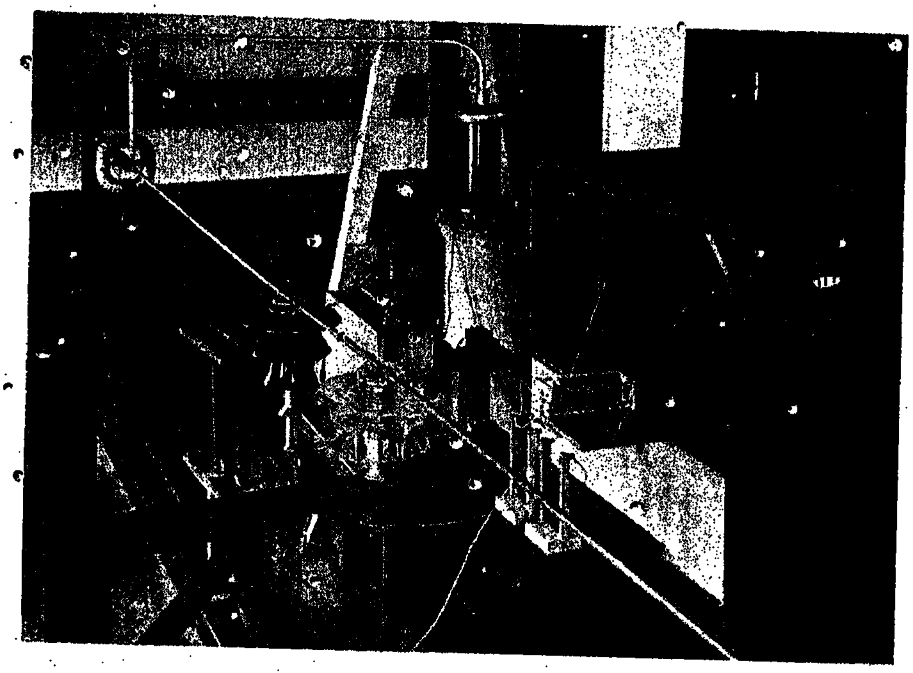

Fig. 3. Apparatus for obtaining cathode ray oscillograms of insulator corona current

Unfortunately the oscillograms do not show the oscillations clearly. This is because that in order to form an image on photographic film it is necessary to trace several successive cycles of corona current on the fluorescent screen. On account of the chance character of corona formation, successive cycles of corona current are not alike, and where the oscillations are the greatest, the variation in successive figures is largest. This variation in the registration of successive cycles is shown on the oscillogram by variations in intensity of exposure and sharpness of the image.

Corona current oscillograms were taken also on a special three-shell 66-kv. porcelain insulator with a silver and bismuth coating on the head and in the pin-hole. This insulator (No. B-6 of Table I) was practically identical with the previous one except for the addition of the metallic coatings. In this case no corona current was observed below 30 kv. The difference in the character of positive and negative corona currents on this insulator was greater than for the standard insulators. The positive current shows much less oscillation than the negative, and the duration of the positive current was observed to be much shorter than that of the negative.

Metallic dielectric flux distributors on this special insulator greatly improved the characteristics from the standpoint of radio interference. The interference starting voltage was increased from slightly above 10 kv. to 23.5 kv., and the maximum corona current at 40 kv. was reduced from 40 to 11 microamperes. However, the voltage gradient was noted to be excessive at the edges of the metallic coatings on the head and in the pin-hole at 23.5 kv., which is only 61.6 per cent of normal operating voltage.

Similar oscillograms were taken for a standard 70-kv. one-piece glass insulator without any treatment to prevent corona formation. These oscillograms show the same general corona current characteristics obtained with the standard porcelain insulator. Cathode ray oscillograms for a similar glass insulator with high resistance iridescent dielectric flux distributors on the head and in the pin-hole revealed no corona current for voltages up to 40 kv. when these coatings were in good condition.

## OSCILLOGRAPHIC STUDY OF RADIO RECEIVER OUTPUT

In order to determine the value of the cathode ray oscillograms of insulator corona currents for indicating the interfering noise that will be produced in a radio receiver, a large number of both Duddell and cathode ray oscillograms was taken of the audio frequency output from a superheterodyne receiver. These were taken with the receiver tuned for a frequency of 1,000 kc. and receiving only the radiation from the laboratory line equipped with one insulator. The circuit conditions and voltages used were the same as those employed when the cathode ray oscillograms of corona current discussed previously were taken.

A typical set of oscillograms for this portion of the investigation may be seen in Fig. 5. In these the polarity and magnitude of the insulator voltage as well as the audio frequency current output of the radio receiver are shown for the standard, three-shell, 66-kv. porcelain insulator for which corona current oscillograms were shown in Fig. 4. It should be observed that the oscillations in the audio output have frequencies reaching values of 5,000 cycles per sec., which is the natural period of oscillation for the oscillograph vibrator element. Therefore the amplitude indications are not very reliable. Notwithstanding this fact, the oscillograms show accurately the beginning of the corona discharge and quite accurately the end of the corona discharge with reference to each half cycle of the insulator voltage. At 14.1 kv. maximum, there is just the slightest trace of interference, occurring at practically the crests of the voltage waves. At 21.2 kv. maximum, the corona starts at a very small electrical angle and at 28.3 kv. maximum, it appears at the zero point of the voltage wave. For higher voltages the corona starts before the voltage wave reverses polarity. For all values of voltage the corona discharge stops at the crest of the voltage wave. This is shown by the fact that at that point the oscillations stop. At the higher voltages the smooth decay of current following the oscillations is due to the recovery of the receiving set from overloading.

The phenomenon of obtaining critical ionizing voltage gradients on the insulator at zero, and even with opposing conductor potentials, is due to the large space charge established in the space and on the insulator surface surrounding the conducting materials where ionization has taken place during the previous half cycle. This is brought out in greater detail in the following discussion.

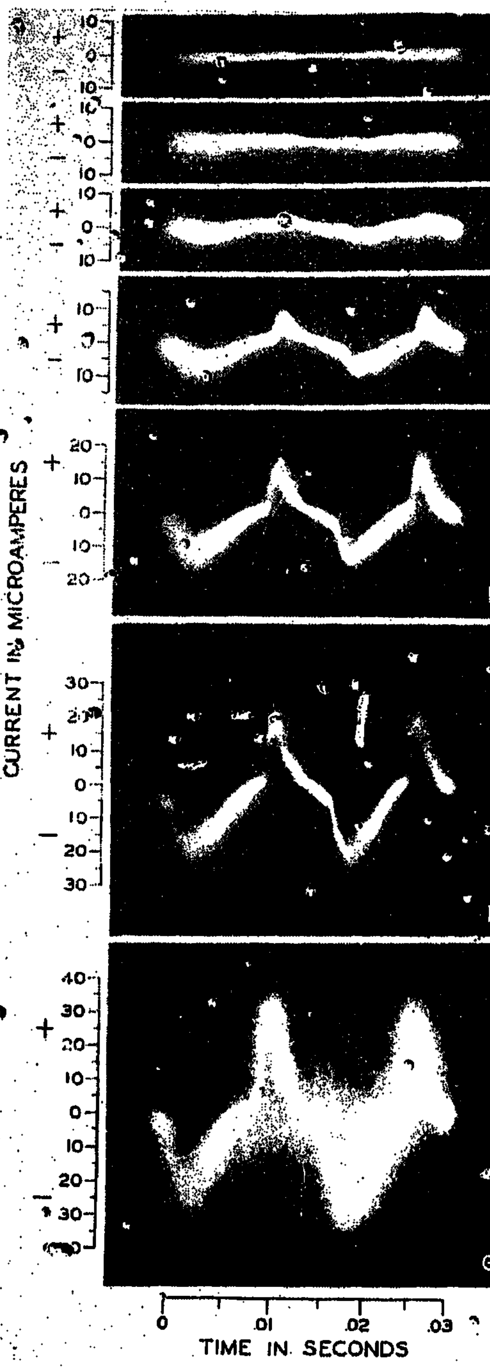

**Fig. 4. Cathode ray oscillograms of corona current for a standard 66-kv. porcelain pin type insulator**

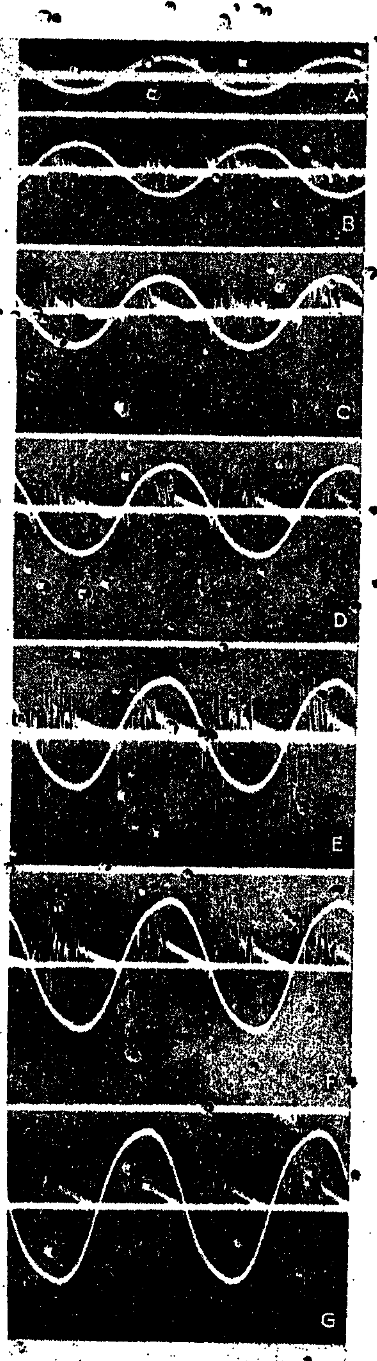

**Fig. 5. Insulator voltage (60 cycle) and output of radio receiver showing noise from corona on insulator of Fig. 4**

| | Insulator kv. conductor to pin | |
|---|---|---|
| | r.m.s. | maximum |
| A— | 10 | 14.1 |
| B— | 15 | 21.5 |
| C— | 20 | 28.3 |
| D— | 25 | 35.4 |
| E— | 30 | 42.5 |
| F— | 35 | 49.5 |
| G— | 40 | 56.6 |

| Test conditions (Figs. 4 and 5) | |
|---|---|
| Barometric pressure | 756.0 mm. |
| Temperature, dry bulb | 21.6 deg. cent. |
| wet bulb | 15.3 deg. cent. |
| Relative humidity | 50.0 per cent |
| Absolute humidity | 94.0 g. per cu.m. |

## A THEORY OF THE FORMATION OF INSULATOR CORONA

A theory of the phenomena associated with corona formation on an insulator can be developed by assuming the initial half cycle of conductor voltage to be either positive or negative. For the following discussion the initial polarity is assumed to be negative and the ionization of the air surrounding the conducting parts and in zones of high voltage stress is assumed to be only the normal atmospheric value at the instant the voltage first is applied.

During the initial negative half cycle, the dielectric field of the negatively charged conductor repels the free electrons and negative ions in the regions of high voltage gradient; when the critical ionizing voltage gradient is reached, they bombard the air molecules with such violence that ionization by collision results. The additional electrons and negative ions produced by collision are repelled from the conducting material by the electric field, and form the major part of an outside negative space charge. The heavy immobile positive ions move relatively slowly toward the conductor in the regions of ionization. In this manner corona increases and the positive ion space charge that accumulates due to the relative immobility of the positive ions subtracts from the negative field of the conductor until the crest of the voltage wave is reached. At this point ionization stops because the space occupied by the corona is completely ionized; the voltage gradient at the outside boundary of the corona discharge is just equal to the critical value and must decrease below this value as the conductor voltage decreases. For the negative conductor condition under consideration the positive space charge limits the corona to a comparatively small discharge distance. Many of the free electrons are swept out of the ionization zone and the loss of positive ions by recombination adjacent to the conductor thereby is reduced to a relatively small number. Large numbers of positive ions always are present therefore adjacent to the conductor; this is such a favorable position that a comparatively small

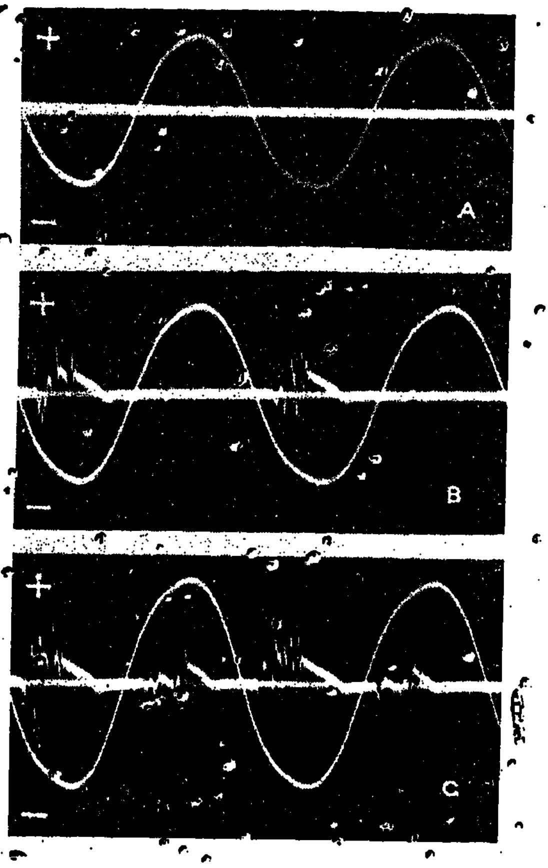

**Fig. 6. Insulator voltage and radio receiver output showing more interference during the negative than during the positive half cycles.**

Insulator kv. conductor to pin

|  | r.m.s. | maximum |
|---|---|---|
| A— | 30 | 42.5 |
| B.— | 35 | 49.5 |
| C— | 40 | 56.6 |

Barometric pressure 760.0 mm.
Temperature
dry bulb 21.5 deg. cent.
wet bulb 16.0 deg. cent.
Humidity
relative 56.0 per cent
absolute 10.6 g. per cu.m.

Porcelain insulator (66 Kv.) with silver and bismuth coating on head and in pin-hole

positive space charge will reduce greatly the field of a large negative conductor voltage at the outside boundary of the corona discharge.

After the negative voltage wave passes the crest and starts to decrease, the negative space charge at the outer boundary of the corona no longer is replenished by new ionization; hence it begins to diffuse and be lost by recombination. This action releases the positive space charge and allows it to move more rapidly back toward the conductor, which movement tends to increase the gradient in the space between the positive space charge and the conductor. Because of the decrease in conductor potential, ionizing voltage gradients prior to actual reversal of conductor potential are reached only when the space charge is very large. The latter phenomenon does occur, however, for all maximum applied voltages in excess of approximately twice the maximum visual critical corona voltage.

When the conductor voltage reverses and becomes positive after the described phenomena have taken place, the dielectric flux of the residual positive space charge adds to the field of the positive potential on the conductor. The addition of those fluxes causes the critical ionizing voltage gradient to occur at lower and lower values of instantaneous positive conductor voltages as the maximum conductor voltage is increased above the visual critical corona value. The resultant positive field accelerates the electrons in the surrounding space, and when high velocity collisions occur with molecules of air, ionization is produced. Large numbers of the electrons liberated are swept from the field and removed by the conductor, leaving more immobile positive ions to add to the positive space charge. This increase in space charge increases the dielectric flux density and extends the ionizing voltage gradient to a far greater distance from the conductor than would be possible with the conductor voltage acting alone. When the crest of the positive voltage wave is reached, the voltage gradient is at maximum and the corona discharge stops because the space occupied by the corona is completely ionized; the decrease in the conductor voltage makes ionization at a greater distance from the conductor impossible. As the conductor potential decreases it drops below space charge potential and a field is established between space charge and conductor. The field produces ionizing voltage gradients before the conductor voltage reverses, when the space charge potentials are very high. This phenomenon occurs for maximum applied voltages in excess of approximately twice the maximum visual critical corona voltage.

During the rise in voltage on the positive half cycle a much larger positive space charge is established than that produced during the same period of the negative half cycle. This is because when the conductor is positive, the positive space charge flux adds to the conductor field and extends the ionization gradient, when it is negative, the positive space charge flux subtracts from the negative conductor field at the outside corona boundary.

When the conductor voltage reverses and becomes negative following the establishment of a large positive space charge in the manner just described, a very high voltage gradient is produced between the negative conductor and the residual positive space charge because of the very short distance between them. When this voltage gradient reaches the critical ionizing value (which may occur before the voltage actually becomes negative) breakdown occurs in the form of minute arcs which neutralize the space charge. These corona arcs produce sudden changes in the electric circuit conditions, thereby causing high frequency oscillations of a violent character.

## Radio Interference from Positive and Negative Corona

Near the critical corona formation voltage the electric circuit oscillations and the electromagnetic radiation resulting from them are inherently much worse for 60-cycle a-c. circuits when the conductor is negative than when it is positive. Theoretical considerations outlined in the preceding paragraphs indicate that this condition is to be expected and experimental investigations show a very decided polarity effect under certain conditions. For the special 66-kv. porcelain insulator with silver and bismuth coatings on the head and in the pin-hole, oscillograms taken show a very striking polarity effect in the interference radiation. (See Fig. 6.)

From the experimental investigations it appears that the marked difference in radio interference when the line is positive and when it is negative, respectively, can be observed only when the insulator has a definite critical corona formation voltage. When the voltage is increased far above this critical value, the polarity effect becomes less marked and at still higher voltages probably would disappear almost entirely. This phenomenon accounts for the fact that practically no interference polarity effect was observable in the tests on standard insulators. (See Fig. 4.) On such insulators there is a heterogeneous group of visual critical voltage gradients that cause corona to form in small areas at various locations for every different value of insulator voltages from approximately 25 per cent normal operating voltage up to the flashover value. There the polarity effect is obscured because when sufficient voltage is applied to produce appreciable corona on the insulator, the regions that go into corona at low voltage are subjected to an excessive voltage gradient and therefore produce practically the same interference on both positive and negative half cycles.

## SUMMARY

The findings of this study may be summarized as follows:

1. Standard multi-shell pin type insulators of conventional design are susceptible to corona formation at three different points.

2. Radio interference and visible corona formation for clean insulators start at the same voltage.

3. Radio interference from insulator corona may be reduced by (a) designing the insulator so as to eliminate regions of overstressed air; (b) providing conducting coatings on different parts to act as dielectric flux distributors; and (c) displacing the overstressed air with an insulating compound.

4. Insulator corona current can be separated from the charging current and studied independently by means of the cathode ray oscillograph.

5. Duddell oscillograms of the line voltage, and the audio frequency output of a radio set receiving the radiation from an insulator or other source of corona, provide an excellent means for studying certain corona characteristics.

6. The radio interference radiation from an insulator having a definite critical corona voltage shows a decided polarity effect for all corona voltages up to approximately twice the critical disruptive value.

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# Engineering Features of Three-Power Locomotives

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**Locomotives for operation from either an external distribution system or an internal power source are especially well adapted to service over portions of road which for economic reasons cannot be completely electrified. Some of the more important engineering features of this type locomotive are outlined in this article.**

THE THREE-POWER locomotive has taken its name from the fact that it may operate either from an external power source, which may be either a third-rail or overhead distribution system, or from two internal sources. The internal sources consist of a storage battery and a generator driven by an internal combustion engine. While the locomotive may be operated from the battery alone, operation on internal power usually is carried out with the generator running in parallel with the battery. The New York Central Railroad now has in service 36 locomotives of this type. These are used primarily in the elimination of steam service on the "West Side" tracks of New York City where the complete electrification with external power would be extremely impractical if not almost impossible. With the advent of electrified suburban passenger service from Hoboken, N. J., the Delaware, Lackawanna and Western Railroad also has put into service two three-power locomotives to aid in eliminating steam from its Bergen (N. J.) tunnels. These are used in a combination of transfer and switching service between that railroad's yards in Jersey City (adjacent to the Hoboken passenger terminal) and the Secaucus yards about 3.5 miles distant.

Perhaps the most outstanding feature of the three-power locomotive is its great flexibility. On both the New York Central and the Lackawanna systems the

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Based upon "Engineering Features of Three-Power Locomotives" (No. 32-2) to be presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25-29, 1932.

service demanded a self-propelled locomotive capable of handling the heaviest type of switching and short transfer work, as well as road freight and transfer service on external power.

Service on the New York Central consists of switching and transfer work in and between yards at three different points on its New York City tracks, with many sidings leading into warehouses and industrial buildings, as well as much trackage on city streets. On the Lackawanna system the transfer work consists of hauling heavy trains at relatively high speeds on external power between the two yards mentioned previously; the switching, which must be done entirely on internal power, consists of hauling these trains into the yards, and partially breaking them up, making up outgoing trains, and hauling them to the electrified tracks. To meet needs of this character the three-power locomotive was developed.

Although the operating voltages of the two railway systems mentioned are widely different (New York Central 600 volts d-c.; Lackawanna 3,000 volts d-c.) the general characteristics and scheme of operation of both locomotives are quite similar. (See Table I.) When using external power the unit performs exactly as a straight electric locomotive although the engine-generator set may be run to charge the battery. On non-electrified tracks, power may be taken from the battery alone; however, if the engine is running, traction and auxiliary power are taken entirely from the engine-generator set up to its capacity, above which the battery automatically assumes the excess load. On light loads the engine-generator may run the locomotive and charge the battery at the same time.

**Table I—Specification Data for N.Y. Central and Lackawanna Three-Power Locomotives**

| | N.Y.C. | D.L. & W. |
|---|---|---|
| Weight of locomotive in running order | 257,000 lb. | 248,000 lb. |
| Rated voltage on external power | 600 (3rd rail) | 3,000 (trolley) |
| Continuous hp. on external power | 1,300 | 1,450 |
| Hourly hp. on external power | 1,665 | 1,600 |
| Continuous tractive effort | 24,600 lb | 22,200 lb. |
| Hourly tractive effort | 34,100 lb | 25,200 lb. |
| Speed on external power at continuous tractive effort | 19.8 mi. per hr. | 24.5 mi. per hr. |
| Speed on external power at hourly tractive effort | 18.3 mi. per hr. | 23.8 mi. per hr. |
| Maximum tractive effort (25 per cent adhesion) | 64,250 lb | 62,000 lb. |
| Traction motors | | |
| Number | 4 | 4 |
| Type | Axle-hung | Axle-hung |
| Voltage | 600 | 1,500/3,000 |
| Gearing | 72/17 | 72/17 |
| Ventilation | Forced | Forced |
| Oil engine | | |
| Type | Ingersoll-Rand solid injection | Ingersoll-Rand solid injection |
| Horsepower | 300 | 300 |
| Traction generator | 200 kw. | 200 kw. |
| Battery | | |
| Type | Exide Ironclad TL-27 | Exide Ironclad MVA-21 |
| Number of cells | 240 | 360 |
| Ampere-hour capacity at 6-hr. rate of discharge | 650 | 340 |
| Kw-hr. capacity at 6-hr. rate of discharge | 301 | 242 |
| Average voltage at 6-hr. rate of discharge | 464 | 712 |
| Connection of cells | Series | Series |
| Grounded at | Negative | Negative |
| Control | | |
| Type | Electro-pneumatic, non-automatic | Electro-pneumatic, non-automatic |
| Motor combinations on external power | 3 | 2 |
| Motor combinations on internal power | 3 | 3 |

GENERAL REQUIREMENTS FOR INTERNAL POWER PLANT

The average power required for switching service is small while the peak demands are relatively large. The theory upon which internal power operation of the three-power locomotive is based is that the battery will provide the excess power required for the peak demands, thereby allowing the engine size to be cut to a minimum. Extensive tests to determine the actual extent of these power requirements in heavy switching service on internal power were run in 1928 on the first New York Central locomotive built. The average output for the maximum observed day for three-shift service was approximately 500 kw-hr. which gives an average load of 62.5 kw. per eight-hour shift. The average work for 65 shifts of three-shift service was 447 kw-hr. per shift. Frequently peak loads as high as 800 kw. were recorded, which is more than twelve times the maximum observed average load per eight-hour shift.

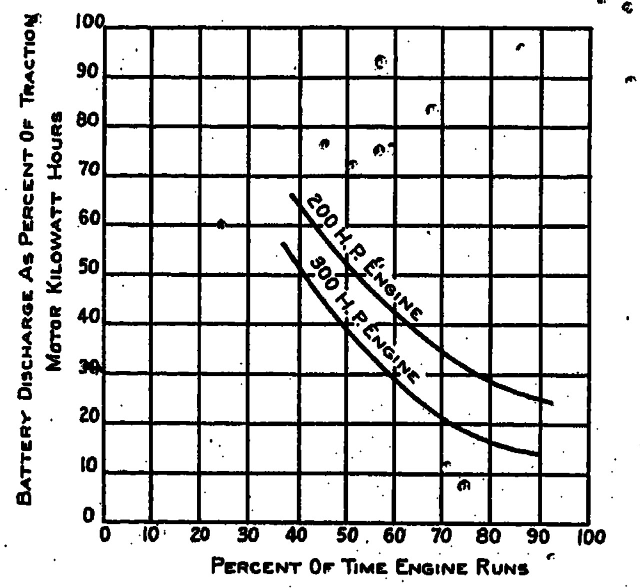

Fig. 1. Battery discharge in heavy switching service on internal power only, as a function of time that oil engine is running

In later tests made on the Lackawanna locomotives, the ratio of the average power required in switching to that required in transfer work proved to be approximately 50 kw. to 450 kw. or 1 to 9. It is believed that this is the first case where actual data have been obtained which show the relative amount of work done on the main and yard tracks. Switching service in these tests called for frequent short periods of operation at from 200 to 400 kw. with peaks of 800 kw., while transfer work had peaks as high as 3,000 kw.

For long battery life and reasonable maintenance, the battery discharge for each 24 hours the locomotive is operating in three-shift service should be limited to 125 per cent of the total capacity at the six-hour rate. To limit the battery discharge to this value successfully it is essential that the correct generator characteristic be used. This characteristic should be such as to insure the engine-generator unit carrying the entire load up to its capacity, but not to recharge the battery so rapidly that the engine must be shut down frequently to prevent overcharging. Without the engine the battery must of course supply the entire load, which results in the discharge over a 24-hr. period being considerably greater than with the engine running most of the time. Initial tests showed that the engine should be run at least 70 per cent of the time to meet these discharge limitations. However, a generator characteristic low enough to insure engine operation 70 per cent of the time is too low to give the battery an equalizing charge; therefore two generator characteristics are necessary; (1) a normal characteristic for regular operation, and (2) a higher or equalizing characteristic for use periodically to give the battery a gassing charge.

Minimum size of the battery is fixed by the traction motor characteristics and locomotive weight on one hand and speed requirements on the other. The former determine the maximum current which may be drawn from the battery as limited by adhesion, and the latter the number of cells. With traction motors in parallel the total current values for the New York Central locomotive at various adhesions range from approximately 2,500 to 3,700 amperes. A battery selected for this locomotive must be large enough to deliver these currents and to carry successfully at least 4,000 amperes for a period long enough to blow the 2,500-ampere battery fuses. Because of the decreased available capacity of the battery at high discharge rates, it is not practical to operate this type of locomotive on internal power at high adhesion and high speed for any great length of time. However, the extreme load conditions given above are possible for short periods and must be met successfully in practical operation.

In case of necessity it is possible to operate these locomotives at high adhesion over considerable distances by running at reduced speeds with the motors in series or series-parallel. In such cases the current to the motors is reduced to one-quarter or one-half of the value which would be required with the motors in parallel for the same total tractive effort. As the engine-generator set will continue to deliver its full power, all of this reduction in current is taken from the battery discharge rate, thus greatly increasing its available capacity. In addition to this, the increase in available kilowatt-hour capacity of the battery increases the duration of the movement and to this extent increases the kilowatt-hours delivered by the engine, thus further increasing available mileage. For fast and responsible operation of the locomotive it is advantageous to have the battery voltage near the rated voltage of the traction motors.

## INTERNAL POWER PLANT OF THE NEW YORK CENTRAL LOCOMOTIVE

As a result of the initial tests and the weight and speed considerations just outlined, a design for the New York Central locomotive was adopted to meet the following specifications:

Battery short time current rating—2 min.—3,000 amperes
Engine hp.—300
Assumed time engine running—85 per cent
Maximum amount battery may be discharged in 24-hr. period (125 per cent of capacity at 6-hr. rate):
812 ampere-hr. in 24 hr.
271 ampere-hr. per 8-hr. shift
114 kw-hr. per 8-hr. shift (average discharge volts 420)
See Table I also

Effect upon the battery discharge of the percentage of time the engine operates is shown in Fig. 1. These curves are plotted from data taken during the tests on the initial New York Central locomotive. For the 300-hp. curve a number of points was obtained between 45- and 75-per cent operation, the curve being extended somewhat beyond these values upon reasonable assumptions. The 200-hp. engine curve is based largely upon assumptions since only one point (93 per cent) was available from the test data, this test being made by

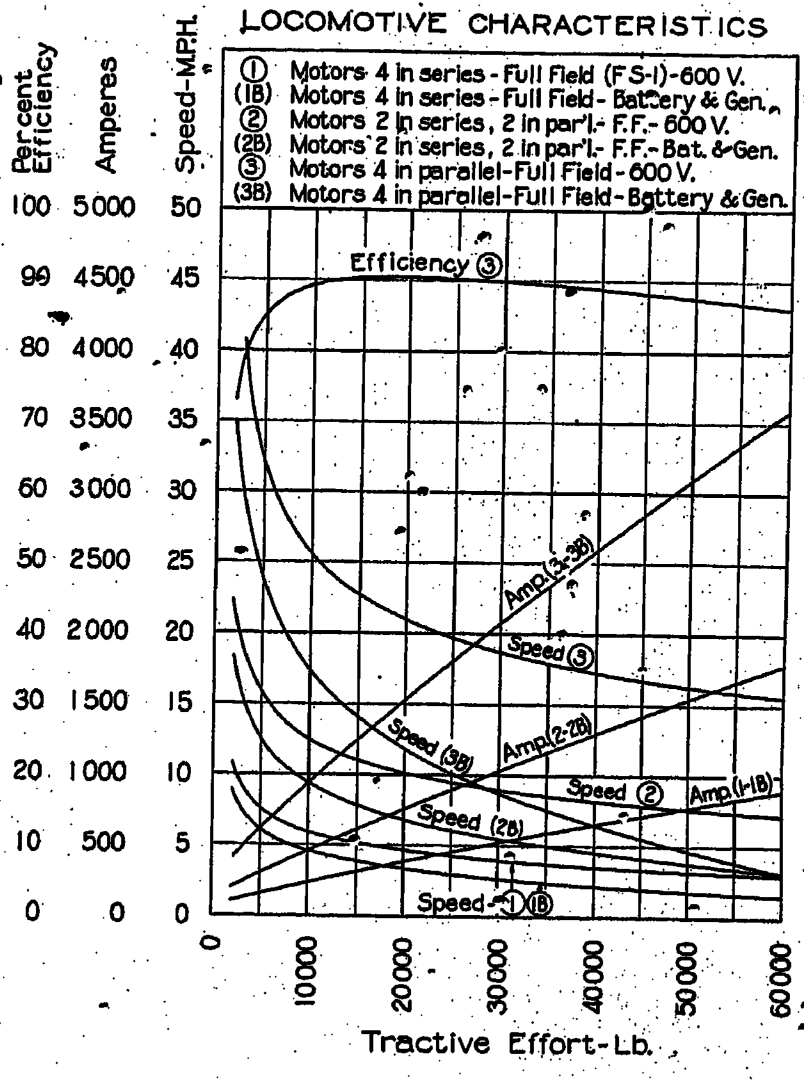

**Fig. 2. Operating characteristics of New York Central three-power locomotive**

setting the fuel finger of the oil engine governor to limit the engine output to 200 hp.

With a 300-hp. engine running 85 per cent of the time the battery discharge will be equivalent to approximately 15 per cent of the power delivered to the traction motors; therefore the maximum average work which the locomotive can do per eight-hour shift when operating three shifts per day on internal power is 114/0.15 = 760 kw-hr. Using Fig. 1 and interpolating for the 250-hp. engine, it may be shown that a 250-hp. engine might have been used successfully with the 301-kw-hr. battery to meet the requirements of 500 kw-hr. per shift. However, it was thought advisable to allow some margin for contingencies; hence a combination of a 300-hp. engine with a 301-kw-hr. battery finally was chosen because of the greater margin of capacity per shift as well as the ability to use an oil engine which had been thoroughly proved in railway service. Characteristics of this locomotive on both external and internal power are shown in Fig. 2.

The oil engine finally chosen for both the New York Central and Lackawanna locomotives is the Ingersoll-Rand 300-hp. vertical, six-cylinder, four-stroke-cycle, trunk-piston, single-acting type with direct fuel injection. The engine is controlled by a constant-speed governor which regulates between 550 r.p.m., full load, and 575 r.p.m., no load. The engine is direct-connected through a flexible coupling to a six-pole, self-excited, compound-wound, 200-kw. generator of the single-bearing type, with multiple self-ventilation.

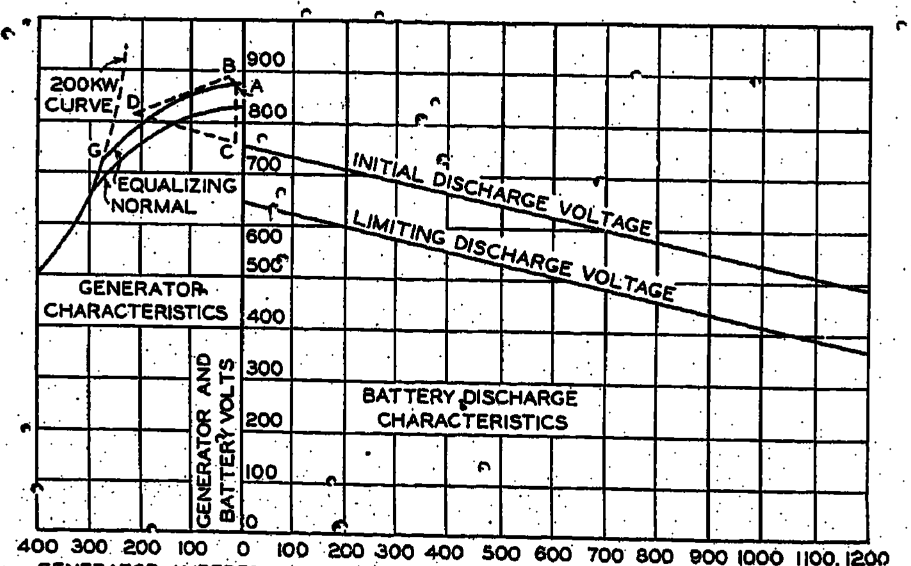

**Fig. 3. Battery and generator characteristics of Lackawanna three-power locomotive**

## SELECTION OF GENERATOR CHARACTERISTIC

In Fig. 3 are shown the generator characteristics and the battery volt-ampere charge and discharge characteristics of the internal power plant of the Lackawanna locomotive. These characteristics are representative of general three-power locomotive practise. When the battery is fully charged, any rate of charge however small will produce gassing; if the charging rate be high enough, gassing will occur with the battery in any state of charge, although the rate may be reduced during the latter part of charge to a value which, unless abnormally sustained or occurring too frequently, will produce so small an amount of gassing as to be practically harmless. This value is called the *finishing rate* and is point *B* in Fig. 3. The charging rate at the end of the charge should be confined between the finishing rate and one-half of the finishing rate. Consequently, line *AB* represents the volt-ampere charge characteristic of the battery at finish of charge condition. The ability of the battery to absorb high charging rates at the start of charge is indicated by point *D*; this is the maximum charging rate recommended; hence, line *CD* is the volt-ampere charge characteristic at start of charge. Line *DB* represents the theoretical generator characteristic which would charge the battery in the minimum time, and *AC* that which would produce a constant current charge at one-half the finishing rate; therefore, the area *ABDC* includes all values of current and voltage that may be used to charge this battery under permissible conditions, and the generator characteristic should intersect lines *AB* and *CD* and lie between lines *BD* and *AC*. The generator characteristic also is restricted by the 200-kw. output curve of the engine-generator set. To allow delivery of approximately full engine load over the whole range of battery discharge, the generator characteristic should pass near point *G* and lie close to the 200-kw. curve at voltages below *G*.

The higher generator curve in Fig. 3 meets these requirements and is suitable for giving the battery an equalizing charge, but is too high to permit the engine to run a sufficient percentage of the time to keep battery discharge within the daily limit of 125 per cent of rated capacity without overcharging. Therefore, the lower curve is used for normal charging and the higher characteristic for periodic equalizing charges.

When using the normal characteristic, the charging rate at the end of charge is less than one-half the finishing rate, but with a properly shaped characteristic and the engine running almost continuously, the battery will be maintained between equalizing charges in a satisfactory state somewhat below full charge. Use of the low generator curve for normal charging has the further advantage of allowing a margin for variation of characteristic between inspections, without the risk of overcharging the battery seriously, which might happen if the engine speed increased and the equalizing characteristic were being used in daily operation.

Control is arranged so that whenever the locomotive is operating on internal power and the traction motors are connected to the battery generator bus, the generator is transferred to the higher characteristic automatically. This is permissible because usually unless the battery is in a very low state of charge, the traction motor load is sufficient to hold the generator voltage below the point where high charging rates will occur. This arrangement permits the use of a more drooping curve without dropping the traction power characteristic below point *G*. The necessity for a drooping curve may be appreciated better when it is considered that the battery is intended to deliver only 42 per cent of its capacity per eight-hour shift, whereas a generator characteristic lying along the line *BD* would give the battery a complete charge in four hours if applied continuously from full discharge and neglecting the small auxiliary load.

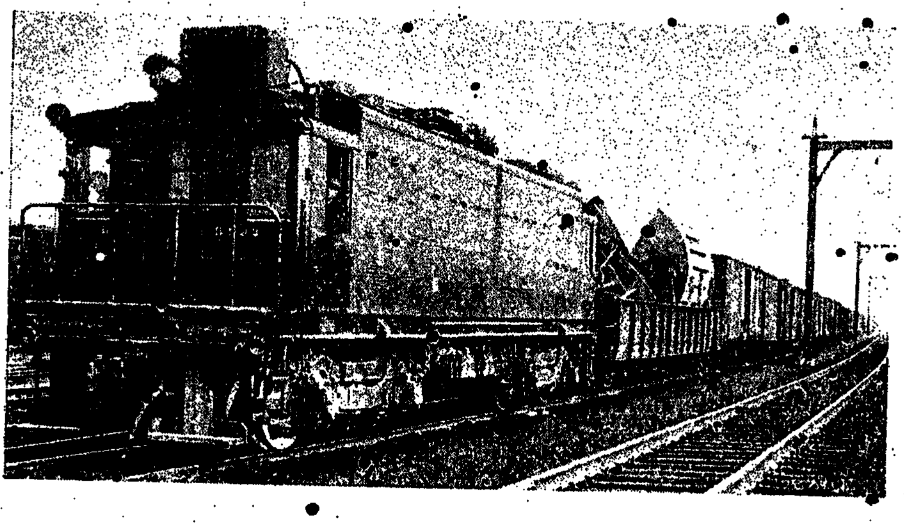

**Fig. 4. Lackawanna three-power locomotive hauling a train on internal power**

Over-all dimensions of locomotive

Length inside knuckles—48 ft. 0 in.
Total wheelbase—34 ft. 1 in.
Height over-all (pantograph locked down)—15 ft. 2 in.
Width over-all—9 ft. 11 in.
Maximum curvature—30 deg.
Truck centers—25 ft. 10 in.

## CONTROL OF THE INTERNAL POWER PLANT

Both the New York Central and Lackawanna locomotives have a three-speed control on internal power. The series or lowest speed connection develops maximum tractive effort with minimum current from the battery generator unit, allowing most slow switching movements to be made almost entirely on the engine-generator set without using battery current.

On both locomotives transfer from external to internal power is controlled by a potential relay and is automatic upon loss of external power, although the automatic feature is selective on the New York Central locomotive because of power interruption on third rail gaps when transfer to internal power is not desired. Transfer from internal to external power is accomplished by turning the controller handle to the "off" position and then notching out, which is necessary because of going from a lower to a higher voltage power source. Indicating lights show whether operation is from internal or external power and whether collector shoes or pantograph are in contact with the third-rail or trolley-wire.

The engine is started by motoring the generator from the battery through the starting resistance, the maximum field for starting being secured by short circuiting the generator shunt-field resistance. A reverse-current relay connects the generator to the battery when the proper generator voltage has built up; likewise it disconnects the generator should the generator voltage drop below that of the battery. To give the battery its weekly gassing charge the equalizing charge switch is closed, short circuiting a section of the generator shunt-field resistance.

Fuel oil is delivered to the engine through an electrically operated valve, which, should low lubricating oil pressure or overspeed occur, is closed automatically by means of an oil pressure switch or speed limit switch, respectively. The same rheostat values are used on both internal and external power on the New York Central locomotive. Control of the battery-generator combination is practically the same on both locomotives. On the Lackawanna locomotive, however, because of the great difference between internal and external power voltages, a set of contactors is employed to rearrange the resistor steps to secure proper operation on internal power.

## AUXILIARIES

Auxiliaries on the New York Central locomotive operate automatically from the third rail when available, but on the Lackawanna locomotive these run at all times on internal power, as this scheme is simpler and less expensive than furnishing auxiliaries for 3,000-volt operation.

Operating cabs are heated by hot water from the oil-engine cooling system. When working on external power, electric immersion heaters operating from the third-rail or overhead trolley are used to heat the cooling system water for cab heating as well as to prevent freezing.

## CONCLUSION

The three-power locomotive has a field of its own and is not intended to supplant the straight oil- or gas-electric unit generally. The work of the locomotive when operating on internal power must be sufficiently intermittent to allow the battery to be maintained in a satisfactory state of charge. Heavy switching and short heavy transfer work on internal power or a combination of both, together with external power operation, offer conditions for which this type of locomotive is best suited. With its internal power feature, this locomotive approaches a universal locomotive for road freight, transfer, and switching service on sections of track which, for economic or practical reasons, could not be electrified completely.

# Standardizing Sizes and Ratings

**Marked economies may be secured by standardizing industrial products to eliminate all unnecessary sizes and ratings. Based upon a system of "preferred numbers," selection of desirable sizes may be made with reasonable accuracy through the use of algebra and geometry supplemented by judgment and common sense.**

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CONSUMERS and producers of industrial products both are vitally interested in the most economical method of standardizing the sizes and ratings of such products. The consumers are interested because they bear every item of cost entering into both the manufacture and the use of an article; the producer because he will not be successful unless he can meet the requirements of the consumer in the most economical manner. In other words, the interests of the two in this respect are identical. If further it is realized that all of us are consumers of industrial products, and that the large majority of us are involved also in one way or another in production, it is evident that the subject is of very general interest and that an early and economically correct standardization of any type of product will prove of advantage to everybody.

However, in spite of the common interests of consumer and producer and the fact that most of us are both of these, a solution of this matter frequently is delayed because there are differences of opinion regarding the best choice of sizes or ratings. Such differences usually are due to the inclination on the part of most individuals to overemphasize those points which in the absence of proper methods of analysis happen to come closest to their attention. For instance, the consumer who is in need of a certain size of article usually hesitates to buy a standard article which is available but larger than he requires, because he feels that in so doing he spends more money than is necessary to meet his requirements. He therefore insists upon the size he needs and thus creates a demand for a large number of sizes. On the other hand, the producer who is put to great expense for tools, stock-keeping, etc., when there are too many standard sizes, frequently will overemphasize the importance of standardizing on as few sizes as possible. All this results in uncertainty and confusion when sizes are selected. Further difficulties arise from the fact that at first, each manufacturer usually establishes sizes and ratings more or less independently of other manufacturers of the same articles.

Later on, but generally not until a conglomeration of sizes has been established, standardization is attempted by those interested. Such efforts are then of course greatly handicapped by the clashing of individual interests, a condition which is unavoidable because of the investments made by the various manufacturers for tools and stocks. Even if a compromise is reached after considerable effort, it is usually at great expense to some or all of those concerned; and because it is agreed upon without due consideration of the best economic results continued waste may be involved in the compromise.

For the purpose of improving the situation just described, a system of "preferred numbers" has been proposed during recent years. Unfortunately so far little use has been made of it, partly perhaps because it has not been sufficiently promulgated, but probably more because industry and the engineering profession have not yet become thoroughly aroused to the fact that this problem of properly establishing sizes and ratings is deserving of most serious consideration. As their designation indicates, these preferred numbers, are certain numbers to be used in preference to any others in selecting standard sizes and ratings. They are arranged in so-called 5, 10, 20 and 40 series, each providing uniform steps between its numbers of 60, 25, 12, and 6 per cent, respectively. Naturally the general adoption of these numbers would be a great step forward, but even after their adoption there still remains the question as to which of the standard percentage steps is the most economical in any given case.

All this indicates a certain helplessness on the part of industry and the engineering profession in this matter of establishing sizes and ratings, and it most certainly emphasizes the desirability and necessity for a more analytical and rational manner of attack upon this important problem. It is the purpose of this article to deal with the fundamentals entering into the problem, and to show that a reasonably correct analysis is possible nearly always through the use of the simplest methods of algebra and geometry supplemented by good judgment and common sense.

## AGGREGATE SIZE MANUFACTUERED

The activity, or number of pieces required, of the various sizes of an article may be influenced by many factors, but usually it may be assumed to be fairly uniform, at least over a certain limited range. With this as a basis let us refer to Fig. 1 in which the hori-

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zontal scale indicates the sizes needed. Let it be assumed that over the range $AB$ there are requirements for the sizes 1 to 7 as indicated. If there are no limitations imposed by tool costs, cost of stock-keeping, manufacturing set-ups, etc., upon the number of sizes which can be manufactured economically, there is no reason for not building the seven sizes just as they are needed. The sizes actually manufactured can then be represented by the straight line $CD$ drawn at an angle of 45 deg. if the vertical scale indicates the sizes actually built. Practical cases of this kind are rare, but nevertheless they do exist. In most cases, however, because of the expense involved for development, tools, setting-up costs for tools, stock-keeping, and other similar factors, we find it necessary to limit ourselves to a reasonable number of definite standard sizes. The range $AB$ shown in Fig. 1 might be covered, for instance, by three sizes, each of which might be assumed to be a certain percentage larger than the previous size.

In such a case the sizes actually built may be represented by the "step" curve *abcdefg*. It is evident at once that the aggregate size manufactured is in excess of that needed and that such excess is represented by the shaded triangles above the line $CD$. For any economic study it will be of value to know to what this excess amounts for various values of $x$ which represents the ratio of the difference between the two sizes to the smaller size. This can be determined by a very simple calculation from Fig. 2, which reproduces one of the steps shown in Fig. 1. It readily is seen that the ratio of the excess size manufactured to the aggregate size needed is the ratio of the area of the triangle $c\,d\,e$ over the area of the trapezoid *klec*. This is found to be

$$S_e = \frac{x}{2 + x} \qquad (1)$$

In Fig. 4 the upper curve marked $K_1 = 1$ has been derived from this equation and should prove useful for ready reference in economic studies of this kind. At times the activity decreases or increases with the size. Such cases can also be analyzed, but for brevity their treatment here is omitted.

## BASIC AGGREGATE MANUFACTURING COSTS

In actual practise we are interested not merely in sizes, but usually even more so in costs. The latter may be studied by reference to Fig. 3, which shows in curve $FG$ the relation of manufacturing costs to size for the range under consideration. Such a relationship is generally available from previous experience in the manufacture of similar articles or designs. Consider again a range *kl* as covered by one standard size and make an approximation by replacing the range *me* of curve $FG$ by the dotted straight line *ne*; from the figure it is evident at once, that the ratio of the excess cost of the aggregate size manufactured to the cost of the aggregate size needed is the ratio of the area of the triangle *edn* to the trapezoid *klen*. This ratio is found to be

$$R_c = \frac{K_1\,x}{2 + x\,(2 - K_1)} \qquad (2)$$

The excess cost ratio for different values of $K_1$ (defined in Fig. 3) plotted against $x$ as calculated from eq. 2 is shown in Fig. 4. In many practical cases in which other factors subsequently discussed are rather simple, suitable values for $x$ can be readily determined from Fig. 4 by using proper judgment, especially when it is intended merely to choose between two values of $x$ as given by the available preferred number series.

## CONSEQUENTIAL COSTS AS DEPENDING UPON SIZE

A number of cost factors will be influenced by the fact that the aggregate size manufactured and used is larger than needed. First among these are the packing and shipping costs, which will be increased. Fre-

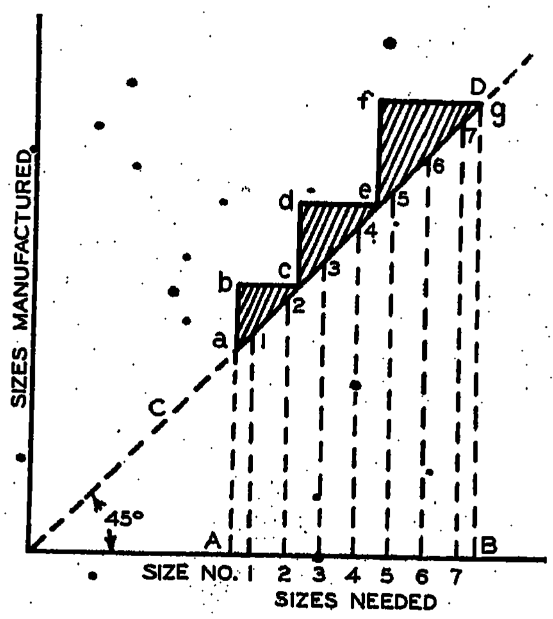

Fig. 1. Diagram illustrating standard sizes

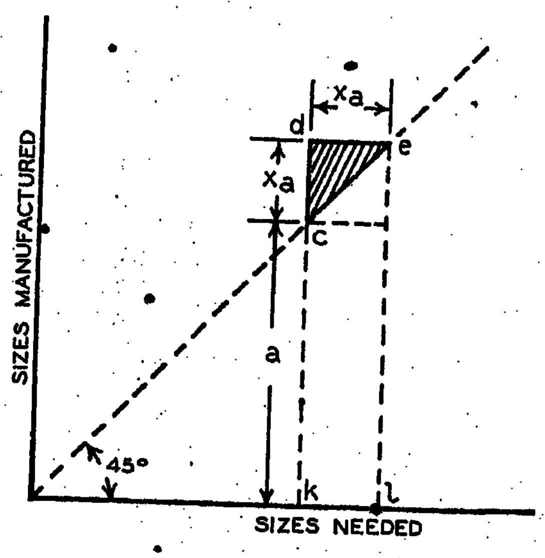

Fig. 2. Excess of manufactured sizes over sizes needed

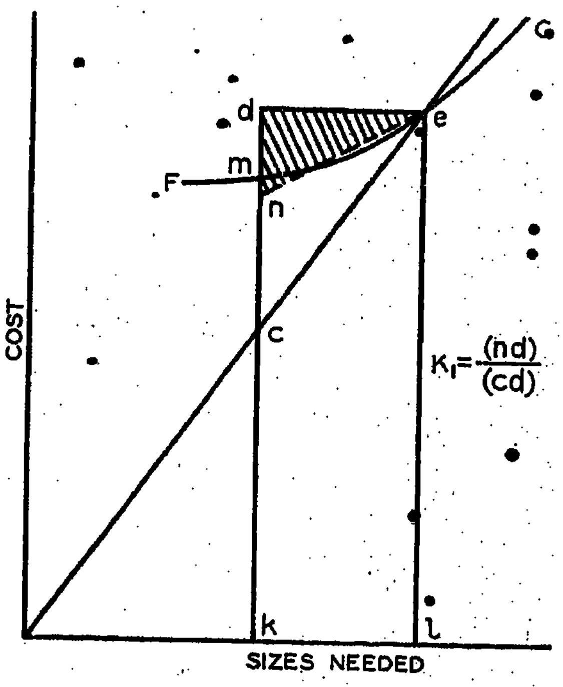

Fig. 3. Excess cost of manufactured sizes over cost of sizes needed

quently the fact that the part manufactured is larger than necessary also results in certain other parts of a design or combination being larger than necessary for the purpose. For example, if a bolt is larger than needed, the stock around this bolt and the cost for drilling and tapping also may have to be increased to some extent; again, if a pedestal bearing is larger than necessary, the bedplate supporting the pedestal will have to be made correspondingly larger. All these factors may be of varying importance even with the same type of article, depending upon the particular application. For this reason an average cost allowance will have to be made for a given range under consideration. These consequential costs will enter into some of the final calculations for the total cost, and can be taken into account simply by adding certain values to the manufacturing costs.

### ENGINEERING DEVELOPMENT AND TOOL COSTS

When a line of articles is developed, there usually are some portions of the cost for tools and development which depend upon the number of sizes manufactured; in other words, the cost of such tools and engineering and development work will be doubled if the number of sizes manufactured is doubled. Assume, then, that in Fig. 5 this part of the development and tool costs is represented by the curve $GH$ in such a way that the ordinates at any one point give the development and tool cost for a size corresponding to such point. Thus the development cost $D$ of the size $le$ would be represented by $lf$. Further, it may be assumed that the total number of pieces to be manufactured during the life of the design over a given range $AB$ of sizes is $N$. If this activity $N$ is uniformly distributed over $AB$ the total number of pieces over the range $ax$ will be

$$N_x = \frac{N}{A\,B}\,a\,x \tag{3}$$

According to previous consideration, the dotted line $he$ may be assumed to be proportional to the sum of the manufacturing costs and the consequential costs of the sizes as needed, so that the ordinate $le = b$ will represent the cost $C$ of the size $le$.

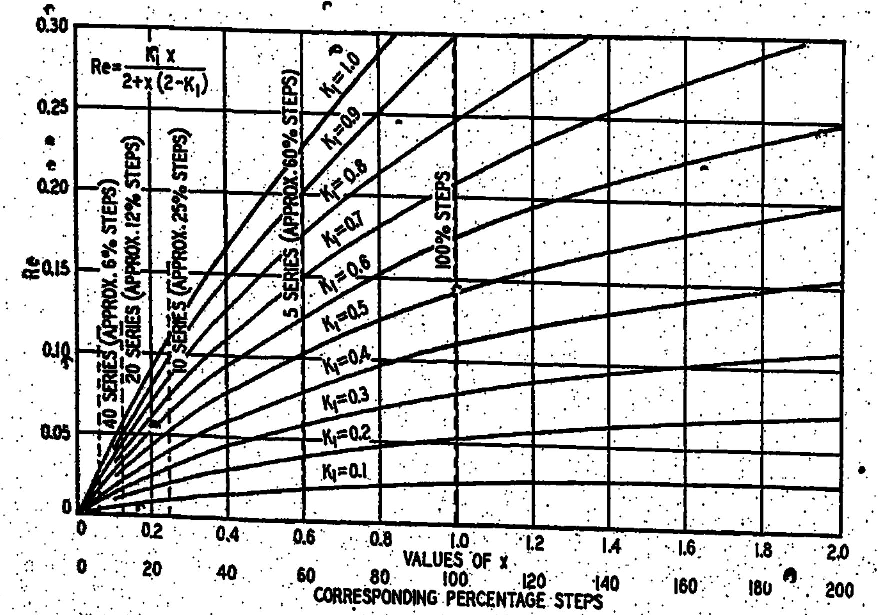

**Fig. 4. Curves showing excess cost of manufactured sizes over basic cost of sizes needed**

The development cost $D$ of size $le$ can be evenly distributed over all the pieces $N_x$ which are manufactured of that size during the life of the design. Therefore, the development cost per piece will be

$$C_d = \frac{D}{N_x} = \frac{D(A\,B)}{N\,a\,x} \tag{4}$$

If $C_d$ in Fig. 5 is entered in the proper scale, the shaded rectangular area may be considered as representing the aggregate development cost for the size $le$.

In addition to the development and tool costs so far considered, there are usually other costs for engineering, development, and tools, which are independent of the number of sizes manufactured. Examples of this are investigations relating to materials or methods, and similar fundamental developments. Another example is certain tool machinery which can and will be used in the manufacture of all sizes. Again, there may be some tools which will have considerable wear and which will have to be replaced repeatedly during the life of the design, so that their total cost will be governed by the total production rather than by the number of sizes. This also holds true when the production is so great that several sets of tools are needed regardless of the number of sizes. The costs of the tools just mentioned may be eliminated from our considerations.

### COSTS FOR MANUFACTURING SET-UPS

The manufacturing costs calculated under the heading "Basic Aggregate Manufacturing Costs" were assumed to be the basic costs and did not include any expense for the setting up of tools prior to actual manufacture. In practise it is usually necessary in changing from the manufacture of one size to another to change certain tools and make different set-ups which frequently involve appreciable expense. It is customary to manufacture at one time a number of pieces equivalent to the average consumption for a number of weeks or months. If such consumption or activity is $N_s$ for the range of sizes $AB$, we find that the activity over the range $ax$ for the same period of time is

$$N_{sx} = \frac{N_s}{A\,B}\,a\,x \tag{5}$$

If the total of set-up costs involved when changing from one size to another is $S$ we find the set-up costs per piece to be

$$C_s = \frac{S}{N_{sx}} = \frac{S}{N_s}\,\frac{A\,B}{a\,x} \tag{6}$$

The previous calculations regarding set-up costs are made under the assumption that there is reasonably great activity for each size and that such sizes are manufactured for stock. There are certain cases of large machinery, however, where practically every machine is manufactured as the order is received; thus a set-up cost is incurred for every order. If the set-up cost is independent of the size, it can be eliminated entirely from our calculations, but if it is dependent upon the size, it may be considered merely as part of the manufacturing cost and treated as such, as outlined under the heading "Basic Aggregate Manufacturing Costs." At times there may be cases between the two extremes just discussed which will necessitate calculations representing a combination of those outlined.

### COST OF STOCK KEEPING

If the articles manufactured are marketed through a great number of small dealers, the total stock they carry and the expense incurred will be greatly influenced by the number of sizes. Assume that the average dealer feels that he has to have one or two pieces of each size, and possibly certain part stock for each size on hand at all times. He then incurs costs for invested capital, storage space, etc., proportional to the number of sizes carried. Similar costs may be incurred also because some of the stock will become obsolete before it can be disposed of, necessitating scrapping or selling at a loss. For calculations here it may be assumed that all of these costs incurred per size are represented by $F$. Assuming further that the activity over the range $AB$ for the life of a given design is $N_f$ the activity over the range $ax$ will be

$$N_{fx} = \frac{N_f}{AB}\, a\, x \qquad (7)$$

This means in turn that the stock-keeping cost to him for each piece is

$$C_f = \frac{F}{N_{fx}} = \frac{F}{N_f}\;\frac{AB}{a\, x} \qquad (8)$$

If the manufacturer keeps only small stocks and the size of his stock is affected by the number of sizes, the same as just discussed for the dealer, the calculations are of course exactly the same. Similarly, the manufacturer's stock in district warehouses may be dependent upon the number of sizes.

In the case of a manufacturer dealing with large quantities, the total stock kept may be practically independent of the number of sizes manufactured. If such is the case, the cost for this stock-keeping may be eliminated from the considerations. This applies also to part stock which is common to all or to several sizes.

### COST OF SPARES AND STOCK IN THE USER'S PLANT

When the user or purchaser of an article finds it necessary to keep a limited stock of each size, the considerations and calculations again are the same as immediately above. The same general principles apply regardless of whether this stock is kept for manufacturing purposes, as spares, or as spare parts for apparatus and machinery operated in the user's plant. One of the principal differences to the user from the costs immediately above may be a rather appreciable cost of spares because (on account of the importance of continuous operation) he may find it necessary to keep a complete spare machine in stock for each size when he has only one or two machines of each size in operation.

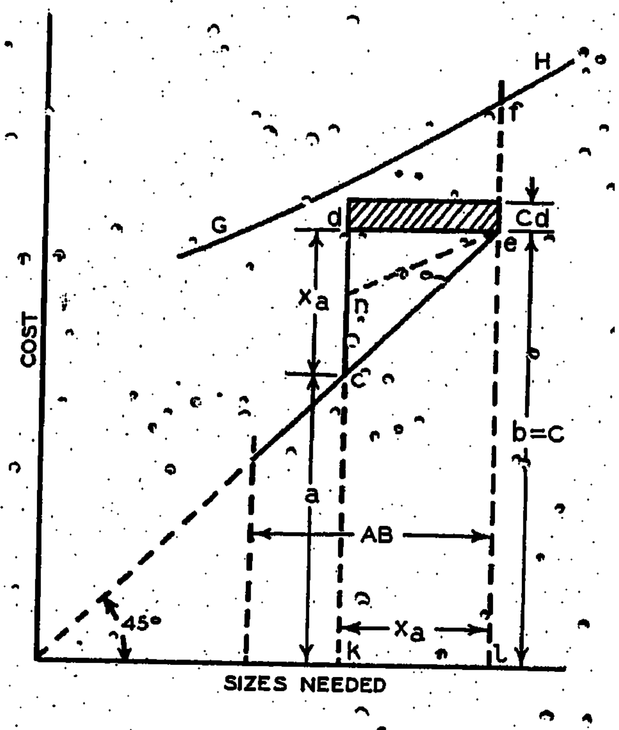

**Fig. 5. Diagram illustrating cost of development and similar costs**

As in previous cases, we can write the following equation

$$C_u = \frac{U}{N_{ux}} = \frac{U}{N_u}\;\frac{AB}{a\, x} \qquad (9)$$

in which $C_u$ is the cost to the user for his stock of spare material, $N_u$ is the activity of the range $AB$, and $N_{ux}$ the activity over the range $ax$.

Certain spare parts common to all or several sizes again may be neglected in this calculation.

### COST OF CLERICAL AND ROUTINE ACTIVITIES

In the manufacture and marketing of most articles there are a great many clerical and routine activities. When an article is first marketed, certain publications and price lists have to be issued. Any part of such expense which is dependent upon the number of sizes may be readily treated as part of the development cost. Certain routine in the works organization, such as the entering of orders, might be considered as part of the set-up cost, while other clerical activities in connection with stock-keeping of course may be combined with the cost of stock-keeping. Then again there may be other routine activities of a different nature which cannot be made a part of any of the costs previously treated, but which in nearly all cases may be taken care of in a very similar manner and by formulas corresponding to those given. Any such clerical or routine activities which are independent of the number of sizes may be omitted from considerations.

### TOTAL FIRST COST

As indicated previously interest is focused chiefly on those costs which are dependent upon the number of sizes. Some of these as indicated by eq. 2 increase with a decreasing number of sizes. While this equation was derived for the basic manufacturing costs, it is equally correct if the cost curve $FG$ in Fig. 3 is assumed to include the costs discussed under the heading "Consequential Costs as Depending on Size" as well as certain costs indicated in the last paragraph under "Costs for Manufacturing Set-Ups." Most of the other costs discussed decrease with decreasing number of sizes.

It is now merely a question of carrying through the development of a formula giving the sum of all costs and finding the ratio $R$ of the total cost to the basic manufacturing cost $C_n$ incurred if each size were manufactured as needed. The value found for $R$ is

$$R = \frac{C_t}{C_n}$$

$$= \left(1 + K_1 \frac{x}{2 + x(2-K_1)}\right) \cdot \left(1 + K_3 \frac{1+x}{x}\right) \qquad (10)$$

where

$$K_3 = \frac{1}{C} \; \frac{AB}{b} \left( \frac{D}{N} + \frac{S}{N_s} + \frac{F}{N_f} \right.$$

$$\left. + \frac{U}{N_u} + \ldots \right) \qquad (11)$$

and

$C$ = the cost previously defined in connection with eqs. 3 and 4, but including where necessary an allowance for costs as discussed in the last paragraph under "Costs for Manufacturing Set-Ups."

We thus have a fairly simple and complete formula from which it is possible to calculate the total first cost for various values of $x$ assuming, of course, that there are at least approximate basic data available from which $K_1$ and $K_3$ can be determined. A typical curve calculated from these formulas is given in Fig. 6. From it can be determined the relation of excess costs over basic manufacturing costs for different steps between sizes.

### UTILITY, SERVICEABILITY, AND PERFORMANCE

Consideration of utility, serviceability, and performance has been left for discussion until now not so much because it is of less importance than the previous items, but because in many cases these three items cannot be made the subject of exact calculation. Their influence therefore often has to be determined by judgment with the aid of such curves as shown in Fig. 6. This will be shown in a number of examples.

Frequently the utility of an article is greatly increased if it completely fills a given space. For example, often it may be desired to use as large a kitchen range as possible within the space available. In view of this it is obvious that a line of ranges inclusive of many sizes will have greater general utility than a similar line composed of fewer sizes. Assume that in a case of this kind the cost curve of Fig. 6 applies, giving a minimum first cost for $x = 0.4$. It is evident at once that on account of the utility feature, the 10 series of preferred numbers, giving 25 per cent steps and corresponding to $x = 0.25$, should be chosen in preference to the 5 series with 60 per cent steps and $x = 0.6$. Even the 20 series, with $x = 0.12$ and an increased first cost of 6 per cent, might be considered. On the other hand, it is more or less evident that since the 40 series would increase the first cost as much as 20 per cent, probably the choice of it would make the manufacturer covering such a large number of sizes non-competitive.

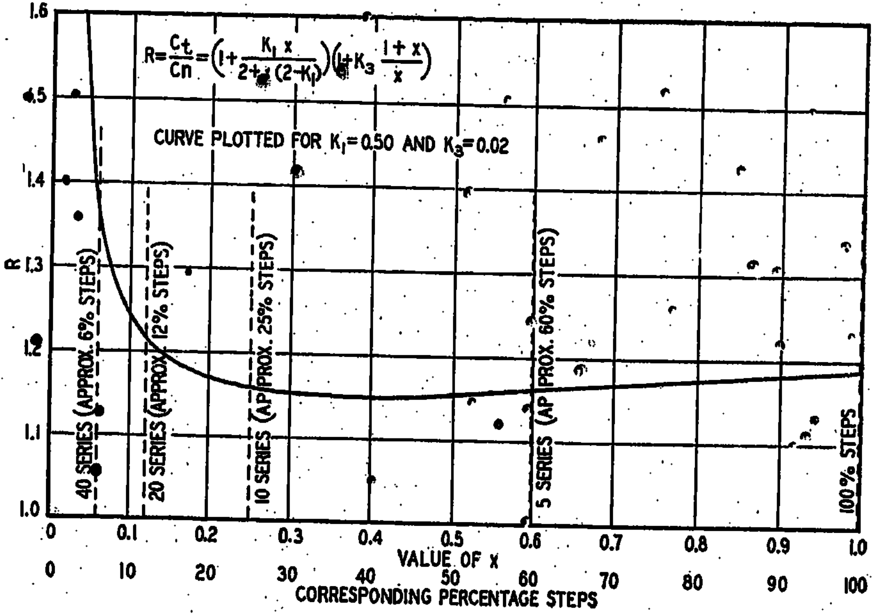

Fig. 6. An example illustrating ratio of total cost to basic cost as related to size of step used

In the case of machinery the question of efficiency or other factors of performance have to be considered. This then may necessitate an engineering study of such factors, and as a result of such study, it may be concluded that the steps considerably smaller than indicated by the curve shown in Fig. 6 should be chosen.

In previous examples the utility and performance considerations tend toward the use of more steps than indicated by the cost curves. An example of the opposite kind would be where the wear and tear of apparatus is of great importance. If but few steps are available, the installed apparatus in many cases will be used below its full rating, which will frequently reduce the average wear. In a case of this kind the use of the 5 series might be resorted to with the cost conditions of Fig. 6, indicating for the 5 series an increased first cost of only 1 per cent over the minimum.

Other instances where the utility favors the use of larger steps are those of machinery where there is a likelihood of the load increasing as time goes on. If in such cases few steps are used and if as a consequence many of the applications are underloaded to begin with, the necessity for installing new and larger machines will be minimized. Another factor which is frequently of importance with regard to the utility of an article is its interchangeability with other similar articles. The possibilities for such interchangeability are better of course with fewer sizes, and therefore with cost conditions as indicated in Fig. 6, this consideration might lead to the choice of the 5 series in preference to the 10 series.

Even when several of the previous factors have to be taken into account, the proper choice of $x$ usually does not present great difficulties after curves as given in Fig. 6 are available.

### MISCELLANEOUS FACTORS

A number of miscellaneous factors may enter into the picture. Assume, for instance, that a new type of apparatus is being developed and that there are uncertainties regarding the design and various commercial factors, all of which may bring about changes in the design sooner than contemplated. If in such a case Fig. 6 indicates the cost condition, it would seem to be good judgment to start with the 5 series, with plans for filling in later on to obtain the 10 series after experience has been acquired.

In actual practise, too few sizes may entail extra expenses which cannot be included readily in the cost calculations as previously given. If, for example, shafts of various sizes are machined from the round stock, the cost of machining many of the shaft sizes will be increased if the number of stock sizes of the raw material is decreased. If Fig. 6 is assumed to apply to a cost study of this kind and the extra cost of machining has not been included in the calculation, it at once is evident that the 20 series is likely to be the best choice. Of course the manufacturer cannot ignore completely his own commercial situation; for example, it is evident that a manufacturer having a greater number of sizes available, is likely to secure a larger proportion of business than one having fewer sizes. This in itself might be a deciding factor in favor of choosing the 20 series in preference to the 5 or 10 series in a case covered by the curve of Fig. 6.

### PREFERRED NUMBERS

In the foregoing, repeated reference has been made to "preferred numbers" and it has been taken for granted in the examples cited that in every case one of the standard series should be chosen. While such curves as shown in Fig. 6 may indicate a minimum for values of $x$, which are different from those corresponding to one of the preferred series, it fortunately is true that near the minimum these curves are rather flat. This means that after considering some of the utility features or similar factors, it nearly always is possible, as indicated by the examples given, to choose one of the standard series to good advantage. There may be exceptional cases where for some reason or other this is not advisable or possible. Thus it may happen that the most economical conditions can be obtained with steps much larger than the 60 per cent steps of the 5 series. For such a case, 100 per cent steps can be readily obtained by using every third step of the 10 series; or 150 per cent steps will result from the use of every second step of the 5 series. In fact, nearly every condition encountered in practise can be taken care of by using some combination of figures chosen from the preferred-number series.

In the space here available it has been impossible to treat all the conditions which may be encountered in the great variety of industrial products; each case will be somewhat different and therefore various methods of attack will have to be used. The principal purpose of this brief outline is to stimulate interest in this important subject of standardizing sizes and ratings. The fundamentals discussed are intended merely to assist in a more rational solution of the problems. If they are judiciously applied, together with an increased adoption of preferred numbers, marked economies to both the consumer and the producer of industrial products undoubtedly will result.

# Cooperative Instruction in Engineering Schools

ALTHOUGH the cooperative method of instruction is assured a permanent place in engineering education, cooperative courses in general still are considered to be in an experimental state of development. In a current A.I.E.E. paper (see footnote) by D. C. Jackson, Jr. (F'30) of the University of Kansas, some well known factors controlling the establishment of this plan of education are reviewed as are some of the general methods of applying it to various types of institutions.

While the author states that "no exact conclusions can be drawn concerning the general principles governing the installation of the cooperative method," he expresses the belief that it is not *universally* applicable to engineering schools and polytechnic institutes; nor is there any one *best* method of using it.

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Abstracted from "Application of the Cooperative Method of Instruction to Engineering Schools and Polytechnic Institutes" (No. 31-113) by D. C. Jackson, Jr., presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

# Steam vs. Electricity for Driving Power Station Auxiliaries

During the past few years important changes effected in power station and system design have reduced operating expenses materially. At present, however, station designers are giving more attention to the reducing of investment costs. This reduction of plant investment quite naturally affects the plant auxiliaries as well as other station equipment. Many large stations built recently have practically all of the essential as well as the non-essential auxiliaries driven by electricity; but in other recent stations steam driven auxiliaries have been used quite extensively. In the light of present conditions and past operating experience, therefore, the A.I.E.E. power generation committee felt that a review of the characteristics and merits of both steam and electric drives would be in order. Accordingly, this committee has sponsored three papers to be presented at the Institute's forthcoming winter convention, and upon these papers the following three articles are based.

## I—Importance of Reliable Auxiliaries

By
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A WELL DESERVED reputation for continuity of service is enjoyed by the electric service industry as a whole. The public has become accustomed to receiving continuous service; furthermore, the large investments of the power station companies and of their industrial customers demand an uninterrupted supply of energy. One of the most important factors vitally affecting continuity of power service is the reliability of generating station auxiliary equipment. Reliability therefore well deserves all the careful attention that has been devoted to it in these articles.

The valuation of variable speed auxiliaries makes an interesting study in the application of auxiliary drive. In the past, station designers have used variable speed drives for fans, pulverizer mills, boiler feed pumps, and circulating pumps quite extensively. However, recent developments in the manufacture of auxiliary equipment and station design have made variable speeds less necessary, the one exception to this trend being boiler feed pumps for high pressure boilers. The article on steam driven auxiliaries (Dryer) brings out very clearly the advantages of the steam turbine as a simple and efficient means for obtaining variable speed drive.

Another important point brought out in these articles is that the type of drive best suited to essential auxiliaries such as fans, boiler feed pumps, and circulating pumps, is related closely to, and dependent upon, the general design of the station. Station design in turn is influenced by the relation of the station to the balance of the power system with respect to interconnections, size, and location. For instance, a power station that forms the chief source of supply for an area, and that does not have reliable interconnections with other power systems, quite apparently warrants more reserve equipment and must have a greater number of steam driven auxiliaries for starting up purposes than a station forming a part of an interconnected system. Furthermore, a new power station forming a part of a large interconnected group may be designed and built to operate at a better load factor than a comparatively isolated station thereby reducing the need for variable speed auxiliary drives.

Selection of an auxiliary drive is affected also by the kind of fuel and fuel burning equipment used, as well as by station space limitations. Gas- and oil-fired boilers as well as those burning pulverized fuel are somewhat more flexible than stoker fired boilers and therefore can be taken out of service more readily with changes in load. This favors the use of constant speed electric drive. On the other hand, where the bin system of pulverized fuel supply is used, exhaust steam usually is required to dry out the coal, thus justifying the use of some steam driven auxiliaries. In addition, if ground

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Based upon "Auxiliary Drive for Steam Power Stations" (No. 32-46) to be presented at the A.I.E.E. winter convention, New York, Jan. 25-29, 1932.

and building costs are high and variable speed is required, the use of steam driven auxiliaries may result in an appreciable saving.

It is interesting to note that the total auxiliary power used by a modern station is a relatively small part of the gross generated power, being approximately from 4.5 to 6 per cent; hence a radical saving in auxiliary power cannot be expected from any type of drive. Likewise, the investment cost in auxiliary power including drive and control equipments is a relatively small part of the total station cost, being in the case cited for electric drive (Smith) approximately 7 per cent of the total station cost. Apparently station designers are more or less free to use either type of drive without seriously affecting either the cost or the efficiency of a power station as a whole. Electric drive is favored for essential auxiliaries from the standpoint of convenience and cleanliness in operation, and also because it is more readily adapted to automatic and remote control, particularly in the boiler room.

As regards maintenance costs, a comparison between steam and electric drive would be of interest; however, representative figures are difficult to obtain, chiefly because sufficient time has not elapsed since the more modern stations were placed in operation. In addition, during the last few years the advancement in station design has been so rapid that it is difficult to find stations of sufficient similarity to make a fair comparison.

In passing to the other two articles of the group it may be said that the treatment is inherently one of generalities because of the many factors that may enter into the selection of an auxiliary drive. Discussion of the subject matter, however, should be of interest in bringing out points for consideration when determining the type of drive best suited for any specific application.

# II—Steam Driven Plant Auxiliaries

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RELIABILITY may be set down as the most outstanding requirement of electric power station auxiliaries since, among other things, an uninterrupted supply of power depends upon the ability of the *essential* auxiliaries to function continuously. Thus any arrangements made for guaranteeing the operation of these auxiliaries should be appropriate to the degree of service reliability expected from the station. These arrangements for station auxiliaries involve the furnishing of a reliable supply of energy as well as turbines, motors, and accessory equipment which are free from physical defects and which possess suitable operating characteristics. Considerations secondary to this first requirement of reliability are simplicity, initial cost, maintenance expense, and economy of power.

For greatest reliability, essential auxiliary driving units must be supplied with energy free from disturbances which would interrupt their operation. To the extent that the source of supply is exposed to those disturbances, arrangements must be made to limit the effect of any single disturbance to as few auxiliaries as possible, and to provide a duplicate source immediately available should the primary source fail. Minor disturbances such as slight reductions in steam pressure or voltage are to be expected and provision against them should be included in the design of the drives. The question which naturally arises then is "to what extent is the provision of a duplicate source of supply advisable when the essential auxiliaries are steam driven; and to what extent when motor driven?"

## RELIABILITY OF AUXILIARY STEAM POWER

Disturbances threatening interruption of the auxiliary service may originate either within or without the station. In properly designed and operated stations with turbine driven auxiliaries, no external circumstances can disturb the characteristics of the steam supply to an extent which will prevent the auxiliaries from always having available sufficient driving power of suitable characteristics. If not anticipated and arranged for, one circumstance which could interfere with the ability of the steam power to sustain the proper operation of auxiliaries would be the sudden imposition of an abnormally large electrical load on the station. By overtaxing the evaporating ability of the boilers, the pressure in the steam system might be lowered to the point at which some essential auxiliaries would "lie down." The station then would fail to deliver not only its additional load requirements but also its original load. With this contingency recognized in the modern station, and provided for by holding banked boilers in reserve, by accepting load at a rate appropriate to the steaming ability of the boilers, the operation of steam driven auxiliary equipment remains immune to external disturbances.

Troubles originating within the station and affecting the steam supply to the auxiliaries enough to prevent their operation could be caused only by conditions resulting in an excessive lowering of the steam pressure at the throttles of the auxiliary turbines. Under such conditions, certain types of pulverized fuel mills which require a substantially constant torque regardless of output would stop. This might result in the boilers,

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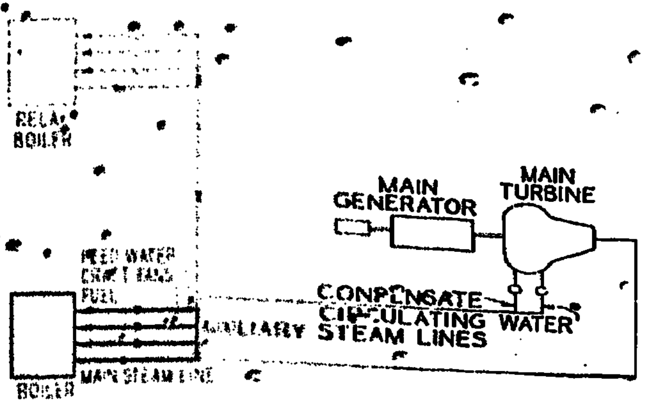

Fig. 1. Energy diagram for a station generator unit with all essential auxiliaries steam driven

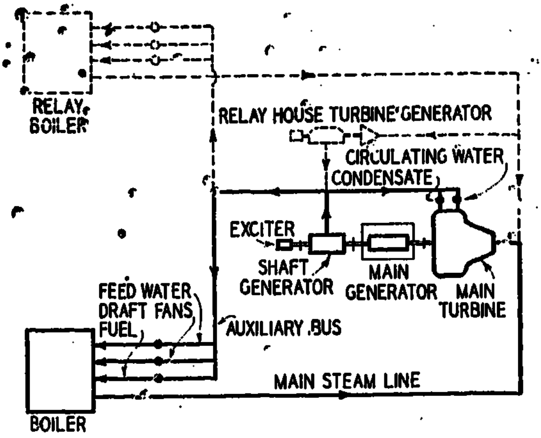

Fig. 2. Energy diagram for station generator with all essential auxiliaries electrically driven

Heavy lines indicate auxiliary equipment and lines which must function continuously to prevent interruptions

being inadequately supplied with fuel, failing to sustain steam pressure. Such excessive decrease of steam pressure, however, is preventable and never encountered in stations properly designed and operated.

### RELIABILITY OF AUXILIARY ELECTRIC POWER

So far as the supply of energy is concerned, a station with electrically driven auxiliaries supplied from a single energy source would not be as reliable as the station with turbine driven auxiliaries. Once the steam energy destined for auxiliaries is transmuted into electrical energy for use in motors, it enters an additional realm wherein its stability is both more sensitive to disturbance and more subject to unexpected attack. Hence, to attain the same degree of reliability as in the station with turbine driven auxiliaries, the station with motor driven units must have duplicate sources of energy.

Since service from the auxiliaries must possess a higher degree of reliability than the main electric power supply, the auxiliaries must be supplied with energy from at least one source not connected to the main generator or to the outgoing lines. This entails furnishing for the auxiliaries at least one generator which may be driven by either the main turbine or by a turbine introduced solely for this special purpose. In important cases, two special generators are used, one driven by each of these turbines. This is done frequently in "downtown" stations of metropolitan systems, where it is considered essential to keep the auxiliary system always free from the effects of external disturbances.

Not only is it necessary to provide special generators and sometimes duplicate distributing systems in stations with motor operated auxiliaries, but it is customary for such important auxiliaries as boiler feed pumps and exciters to rely upon turbines as an ultimate resource.

### RELIABILITY OF TURBINES AND MOTORS

The ultimate reliability of any auxiliary equipment is the compound reliability of its power supply and of the performing abilities inherent in the apparatus itself. Regarding the inherent structural qualities of auxiliary turbines, these machines in their main parts are sturdy, and, as a concession to low initial cost, simple and inefficient compared to the main turbine units. Their parts most questioned are the reduction gears, governors, and valve mechanisms. However, the art of gear-cutting now has been developed so that gears seldom give trouble without ample warning. Governors and valve mechanisms are less certain in operation unless particular skill is applied to their design.

As a basis for evaluating the degree of structural reliability of turbines, they may be compared with the more usual types of motors: the squirrel cage, and the adjustable-speed wound-rotor types. The simplicity of the construction of squirrel cage motors and their accessories probably place them in approximately the same grade of inherent reliability as turbines. Wound rotor motors and their accessories, however, involve parts and constructions which may be preferred only through consideration of power economy. Thus, regarding inherent qualities, it might be said fairly that in the case of constant speed equipment, steam driven auxiliaries are as reliable as those electrically driven; and in the case of variable speed equipment, they are more reliable.

A further aspect of inherent performance reliability in the driving apparatus itself is the relative ability of turbines and motors to drive variable speed equipment smoothly and without transitional disturbances, particularly draft fans. On such duty, the turbine, with its infinite number of speeds, performs evenly. The wound rotor motor, with its step action transition in speeds, is more likely to cause disturbance in burner flames; and further operating complications are encountered in changing from the motor of one speed to that of another.

### RELATIVE EFFICIENCY OF TURBINE AND MOTOR DRIVES

Despite their reliability and simplicity, turbine driven auxiliaries were displaced to a large extent when it was discovered that a fuel saving could be made if steam for producing auxiliary power first was passed through efficient main turbine units to produce electric energy, and then extracted for water heating, instead of being passed through small inefficient turbines driving auxiliaries mechanically and then into feed water heaters. The fundamental reason for this gain in economy is that the surplus energy thus made available is produced much more economically than the rest of the station output energy because the steam required for generating this surplus energy extracted is for heating the boiler feed water. As a result, this steam is utilized at a station thermal efficiency of between 90 and 100 per cent, whereas the steam used for generating the rest of the output energy is carried into the condenser, where most of its original heat energy is lost, and so is used at an efficiency between 20 and 35 per cent.

With regard to the economy actually effected by these changes the examples illustrated in Figs. 3 and 4 show that by substituting motors for turbines on all essential auxiliaries, and by heating the feed water with extracted steam instead of auxiliary exhaust steam a modern station's net output for a given fuel consumption is increased at maximum load about 1.75 per cent; the over-all thermal efficiency of the turbine-driven auxiliary station is 24.4 per cent; for a station with motor drive it would be 24.8 per cent. In this comparison other conditions have been kept similar. It may be observed that in Fig. 3 less steam is needed for water heating than in Fig. 4. This is because the auxiliary turbine in Fig. 3 is inefficient. As a result, hot steam is exhausted, less of which is required for feed water heating than is needed of the cooler steam extracted from the efficient main turbine; however, the greater the percentage of the total steam in the main turbine which can be extracted and used for heating, the smaller the remainder to go into the condenser and the greater the net station output for the same fuel consumption.

Not as a principle unique to either turbine or motor drives, but as one common to both, it should be realized that the station efficiencies shown in Figs. 3 and 4 could and should be increased by heating the feed water further than is shown in these examples by extracting steam from one or two high temperature points of the main turbine. Moreover the 1.75 per cent advantage attained in the station shown in Fig. 4 would have been slightly greater if, instead of using one point of extraction, two had been employed to heat the water to the same temperature; and due alone to the stray losses encountered in actual operation, advantage in favor of electric drive might be as high as 2.5 per cent.

Difference between the efficiencies of the two stations compared would have been very much less if the high efficiencies now obtainable in auxiliary turbines had been assumed instead of the low efficiencies actually taken as better representing common practise. Also, it should be understood that the relative efficiencies of the two stations were estimated for only one station load; with both stations operating at their maximum output, and the auxiliary turbines and motors performing at their maximum loads, and hence at their optimum efficiencies.

## Power Consumption

To ascertain the total difference in power consumption between steam and electric driven auxiliaries over the whole working range of the boilers and turbine generators, and hence the net annual saving in fuel, requires a determination of the power taken at partial loads by both types of drives. This was done by analyzing separately the power input to each essential auxiliary when driven by turbines, squirrel cage, and adjustable-speed wound-rotor motors. In the analyses based upon power output of the boiler, that output was reckoned as the power which the main turbine generator would produce with the quantity and quality of steam delivered by the boiler at its different loads. The power consumed by the turbine driven auxiliaries in all cases was calculated as the power which the quantity of steam used in these auxiliaries would have produced if used instead in the main turbine generators. These analyses represent the performance of equipment in stations having large boilers and turbine generators, where the auxiliary turbines also would be large and slightly more efficient than those often used. However, turbines having higher efficiencies than those assumed in this analysis are now in operation on auxiliary service.

Results of these analyses showed that:

1. For such auxiliaries as circulating water pumps and fuel pulverizing equipment, where the output is substantially constant throughout a wide range of load on the main units, and for which constant speed squirrel cage motors are suitable, the electric drive maintains throughout the entire load range its relative efficiency over the turbine drive.

2. For auxiliaries such as boiler feed pumps and draft fans, in which the output varies with the load on the main units, the squirrel cage motor rapidly loses advantage in the power saving which electric drive gives at maximum load; below approximately 85 per cent load on the main units it is less efficient than the turbine. At lower loads, the initial relationship between the two drives can be reestablished by transferring the load to a lower speed motor, but upon reducing the load still further, this motor will in turn become less efficient than the single turbine.

3. The superior economy which the adjustable-speed wound-rotor motor gives at maximum load over turbine drive diminishes greatly as the load decreases and vanishes at small loads unless operation is transferred to an additional lower speed motor.

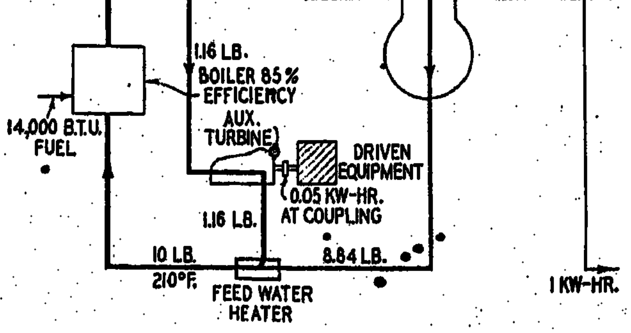

**Fig. 3.** Station efficiency diagram with all auxiliaries steam driven

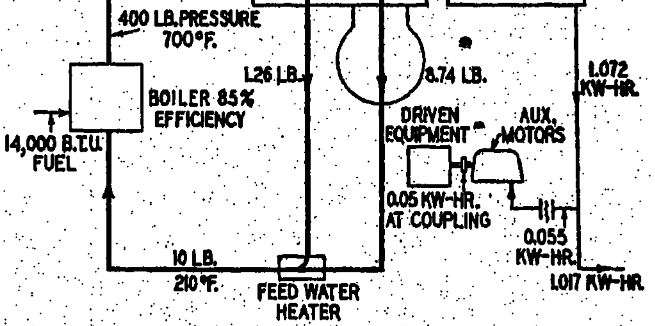

**Fig. 4.** Station efficiency diagram with all auxiliaries electrically driven

## RELATIVE OPERATING COSTS

Conclusions just outlined indicate that from considerations of power consumption, the most favorable application for turbine drive is on equipment like draft fans which, having to traverse a wide range of speed and load, use more than one motor when electrically driven. Even on this application the electric drive saves power; but it involves a larger investment in both driving and generating equipment. Regarding the investment in driving equipment, it is estimated that for large boilers having a maximum output of the order of 500,000 lb. of steam per hour, and with two wound rotor motors per fan, the installed cost of motors, controllers, and wiring for both forced and induced draft fans would be about $10 per rated fan horsepower more than for turbines with their valves and piping.

Regarding the investment in generating equipment assessable against the fan drives, if the fans are electrically driven, and all equipment usually provided for normal and emergency supply assessed, the turbine room cost will be found to increase about $49 per installed fan horsepower. If the draft fans are steam driven, 0.7 per cent more total evaporating capacity is needed than if motor driven; as a result the boiler room in this case costs about $12 more per installed horsepower than in the other case. Those investment costs are based on a total station cost of $95 per kw. output.

On the basis of the foregoing, the total investment incident to the electric drive for fans will be $37 higher per installed fan horsepower than for the turbine drive. If the annual charges on this higher investment is less than the cost of fuel per installed horsepower saved by the electric drive, then motors would be more economical than turbines, and *vice versa.* Seldom, however, would motors be more economical. Even with coal at $4 per ton and a capacity use factor of 100 per cent, the combined fuel cost and fixed charges would be less for the turbine drive than for the motor drive. In plants designed to deliver large quantities of steam for industrial uses or for heating, the economic balance is usually in favor of turbine drive regardless of load factor and fuel cost.

## FUTURE DEVELOPMENTS

To realize fully the advantages obtainable by using auxiliary turbines in conjunction with large main units, more efficient designs and methods of application become desirable, practicable, and commercially feasible. With the conventional designs and applications of these machines, more stages and larger diameters can be used to raise the efficiency at maximum load; however, care must be taken that the gain is not so obtained at the expense of inefficient partial-load operation.

Novel means for securing high efficiency have been adopted in turbines recently installed in one particular large central station; there, not only high rotative speeds and many stages of highly refined design have been introduced, but the steam is passed in series through two turbines. For stations of high steam pressure (600 lb. per sq. in. and more), still other means may be evoked to improve the efficiency of auxiliary turbine operation, as indicated in Fig. 5. Here the improvement is derived through using machines of conventional design, but with novel steam connections. These features contribute to low initial cost of machines and piping, and low maintenance; but much care and some ingenuity of design is required to protect operating continuity while preserving simplicity of design and avoiding undue piping complications.

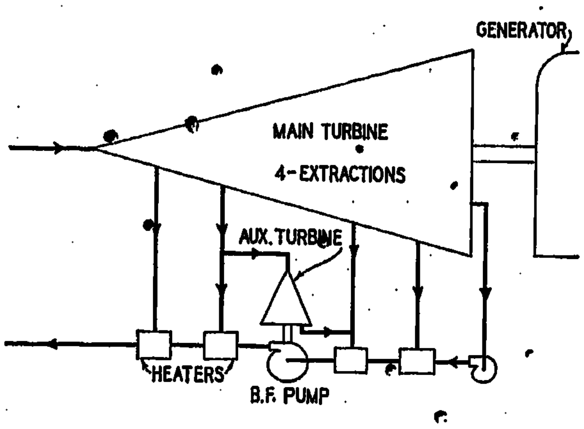

**Fig. 5. Steam and exhaust connections for auxiliary turbines in a typical high pressure station**

In regards to turbine gearing, this accessory usually performs quietly and satisfactorily. It is desirable, however, that still more attention be given to its design and manufacture so as to remove completely the objection to turbine auxiliaries still offered in some quarters where objectional gear noise has been experienced.

While it is indicated that the immediate development of the auxiliary turbine will be along the lines of higher efficiency and greater refinement in mechanical detail, the development of electric drive should be directed toward greater simplicity and lower installation cost. Greater sturdiness of variable speed motors is desirable as is also wider speed ranges; but the greater field for improvement is in distributing systems and control equipment. It is desirable to retain the efficiency and convenience of motor drives without sacrificing reliability, but at substantially lower cost. At the moment just how this end may be accomplished is not clear; but the problem is receiving the attention it deserves, and the great variety of systems adopted in stations built recently indicates that plant designers are far from satisfied with conventional systems and are striving to produce something better.

## CONCLUSIONS

Noteworthy conclusions brought out by the foregoing discussion are summarized briefly in the following paragraphs:

1. At present the turbine constitutes the simplest and most reliable drive for steam power station auxiliaries. For applications requiring extreme protective measures, the simplicity and reliability of turbine drive may warrant its selection for all essential auxiliaries.

2. For maximum load conditions an improvement in over-all fuel economy of the order of 2 per cent will result incidental to the use of motor drive instead of turbine drive for all essential auxiliaries; with both drives; steam would be extracted from the main turbine for feed water heating, more being drawn where motor drive is used.

3. For constant-speed auxiliaries the economy due to motor drive is greater at partial loads than at maximum load.

4. For variable-speed auxiliaries the advantage in economy with motor drive is slight at small loads.

5. Under most conditions the total annual expense for draft fans and perhaps for boiler feed pumps, including fuel costs, maintenance, and capital charges, will be less with turbine drive than with motor drive.

6. There is an element of convenience in the starting and stopping of motor drive which commends it to the average operator, other considerations being approximately equal.

7. The use of turbine drive is not justified for non-essential auxiliaries (which may stop for a short time without inconvenience) these ordinarily being driven at constant speed.

8. Future developments may change the relative status of two drives; but indications are that in the immediate future progress will tend to decrease the advantage in fuel economy which the motor now possesses, and to increase the turbine's advantage of reliability.

# III—Electric Drive for Plant Auxiliaries

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A REVIEW of the history of auxiliaries for steam power stations shows a gradual change from complete steam drive to the other extreme of complete electric drive, except for a few reserve steam driven auxiliaries such as boiler feed pumps and service pumps. During an intermediate period, dual steam and electric drive was used quite extensively for some of the essential auxiliaries, but the number of dual drives appears to be diminishing steadily.

Higher efficiency of electrically driven auxiliaries receiving their power from the efficient main turbine or house turbine, as opposed to small inefficient turbine driven auxiliaries, always has been attractive to the station designer. However, lack of confidence in the reliability of the early forms of electric drive for essential auxiliaries retarded its general adoption until more operating experience was obtained and reasons other than greater efficiency appeared.

The change from steam to electric drive is due largely to an increasing feeling of confidence in the reliability of electric drive, an increasing appreciation of the simplicity and flexibility of electric drive, and important changes in boiler and turbine practise. Confidence in electric drive has been strengthened by improvement in the manufacture and application of electrical equipment, the proved value of station and system interconnections, and a record of successful operating experience. The convenience and flexibility of electric drive are known generally, but will be discussed more in detail later. Important changes in boiler and turbine practise that have influenced the use of electric drive are multi-stage bleeding of turbines for feed water heating, the use of higher steam pressures and temperatures, the development of larger boilers and turbines with their multiplicity of similar auxiliaries, and, to some extent, automatic combustion control.

## COMPARATIVE RELIABILITY OF STEAM AND ELECTRIC DRIVE

Reliability always has been considered the chief requirement for essential auxiliaries; steam is considered more reliable than electric drive chiefly because it is a more direct method of obtaining power. Electric drive introduces additional apparatus such as generators, transformers, and switching and control equipment between the boilers and the auxiliary to be driven. If the electric auxiliary is connected directly or indirectly to the main bus, it is exposed also to the effects of line disturbances. Performance of the intermediary equipment required for electric drive now will be considered from the viewpoint of reliability.

Main and house turbines probably are more reliable than efficient auxiliary turbines; furthermore, the larger units receive much closer attention than could be given economically to auxiliary turbines. Concerning the generators, statistics show that failures are extremely rare, especially since closed ventilation systems have been used; but in case failure of the main generator should occur, there is usually no immediate need for the auxiliaries associated with either the generator or the boilers. Auxiliary transformers have an equally good record for freedom from trouble. Modern switching and control equipment too in recent years has given but relatively little trouble, especially when selected and installed with the usual liberal safety factors.

A large proportion of the motors used for electric drive is of the squirrel-cage induction type which is unusually sturdy, and which readily permits full voltage starting with its inherent simplicity of control. However, when correctly applied and maintained, other types of motors also have given good service. Furthermore, improvements in insulation and bearings have made motor coil failures rare.

In regard to the reliability of power supply for electric auxiliaries, the extensive use of bus and feeder reactors, and diversity of power feeds, have tended to minimize the effects of line disturbances. The present trend toward faster operation in oil circuit breakers also

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Based upon "Electrically Driven Auxiliaries for Steam Power Stations" (No. 32-6) to be presented at the A.I.E.E. winter convention, New York, Jan. 25-29, 1932.

will minimize the effects of line disturbances. From these facts it seems apparent therefore that reliable service may be expected from electric drive when applied correctly.

### SIMPLICITY AND FLEXIBILITY OF ELECTRIC DRIVE

It is difficult to conceive of a simpler drive for rotating equipment than the squirrel-cage motor. Perhaps, however, the greatest advantage in simplicity of the electric motor versus the steam turbine lies in the method of control. A motor for instance may be started and stopped in a fraction of a minute simply by pushing the button, whereas the ordinary small auxiliary turbine usually requires a preliminary warming up. Besides these advantages the convenient control of auxiliaries from a few centralized points, made possible by electric motor drive, often permits a reduction in the station operating staff and contributes toward better efficiency of operation.

Flexibility likewise is an important factor in auxiliary equipment especially from the viewpoint of station design. Here again the almost unlimited flexibility of electric drive gives it a great advantage over steam, as evidenced by modern boiler combustion control systems. The absence of steam piping to the turbine and boiler room auxiliaries, made possible by electric operation results in less congested basements and thereby facilitates station design, operation, and maintenance. Furthermore, in obtaining the station heat balance electric drive provides greater flexibility than steam.

### MODERN TRENDS IN STATION DESIGN FAVOR ELECTRIC DRIVE

Selection of the type of drive for a station's auxiliaries usually is not made entirely on the basis of the relative performance of motors and turbines, but is determined to a large extent by the general design of the station. One of the most important changes in station design and one which has tended to increase the use of electrically driven auxiliaries, is the general adoption of the multistage bleeding cycle for boiler feed water heating. Although complete motor drive for auxiliaries is not required where the stage bleeding cycle is used, electric drive for all auxiliaries in such stations will (1) decrease the B.t.u. per kw-hr. rate of the station approximately 2 per cent; (2) simplify operation by automatically varying with load changes the steam extracted for feed water heating, and (3) simplify the station heat balance system by obviating the transfer of auxiliary load with varying station load.

Another factor favoring the choice of electrically driven auxiliaries is the use of higher steam pressures and temperatures in modern stations. This is because (1) small high pressure auxiliary turbines cost much more than small low pressure turbines, and (2) higher pressure turbines are harder to maintain at their full efficiency and capacity. Operating experience with small turbines indicates that their efficiency falls off rapidly (sometimes as much as 50 per cent) unless they are carefully maintained. This diminishing of efficiency is due to an accumulation of scale in the steam passage; the effect obviously is more pronounced in high pressure turbines because of the smaller clearances.

The trend toward larger stations, which also involves of course larger boilers and turbines, is still another factor in favor of electric drive. These larger units permit the economical use of two or more similar auxiliaries per unit which allows for diversity in the auxiliary power supply and thus increases the reliability of electric drive. Furthermore, a more reliable unit system for auxiliary power supply is justified in these larger stations wherein all essential auxiliaries for a main generator are supplied directly or indirectly from the generator itself.

### COST CONSIDERATIONS

In addition to the many aspects of the choice of auxiliary drive already discussed, any comparison between the two drives introduces at least one other important factor subject to considerable debate—the cost of an electric auxiliary power supply that can be considered equally as reliable as steam. Naturally, the cost of any power supply system involves first of all the amount of power required to drive the auxiliaries.

**Table I—Power Required for Electrically Driven Auxiliaries in a Modern Large Power Station**

| Subdivision | Per Cent of Total Auxiliary Power |
|---|---|
| Coal preparation | 22.0 |
| Boiler feed pumps | 22.0 |
| Turbine auxiliaries | 22.0 |
| Forced and induced draft fans | 20.0 |
| Heater drain pumps | 3.8 |
| Service pumps | 2.6 |
| Station lighting | 2.4 |
| Coal handling | 1.6 |
| Miscellaneous auxiliary power | 1.5 |
| Ash sluice pumps | 1.0 |
| Air compressor | 0.7 |
| Dust precipitators | 0.4 |
| Total (5.5 per cent of gross generated power) | 100.0 |

For an electrically driven auxiliary system the amount of power required is relatively small and depends to a large extent upon the type of fuel-burning equipment used. For a plant burning pulverized coal, from 5.5 to 6.5 per cent of the total gross power generated is required for the auxiliaries; for one employing stokers, from 4.0 to 5.0 per cent; and for one burning gas or oil, from 3.5 to 4.0 per cent. The station load factor and nature of condensing water supply also affect the amount of auxiliary power, but to a lesser extent.

In Table I is given an approximate subdivision of auxiliary power for a typical modern 650-lb. steam-generating station of approximately 200,000-kw. capacity, entirely equipped with electrically driven auxiliaries and using the unit system of pulverized fuel equipment. A study of this tabulation indicates that at best the possibilities of further saving in the amount of auxiliary power appears to be limited to about 1 or 2 per cent of the gross generated power.

### Table II—Investment Cost of Electric Equipment to Drive Auxiliaries of a Modern Large Station

| Subdivision | Approximate Per Cent of Total Station Cost |
|---|---|
| Prorated share of cost for portion of turbo-generator units used for auxiliary power | 0.8 |
| Auxiliary power distribution system, including transformers | 1.0 |
| Motors | 1.2 |
| Control equipment for motors | 2.0 |
| Cable and conduit for motors and control equipment | 2.0 |
| Total | 7.0 |

Investment in equipment is the next cost item considered. Accordingly, in Table II is given an approximate major subdivision of investment costs for the electrical parts of the auxiliaries for the same typical 200,000-kw. station. This station utilizes for auxiliary power two 4,000-kw. shaft generators, and two 9,000-kva. transformer banks connected to the main bus. The main switching equipment and the 2.3-kv. auxiliary switching equipment are of the vertical-lift metal-clad type; for the 440-volt motors air circuit breakers and magnetic switches are used. The boilers are supplied with full automatic control.

In Table II only the prorated share of the cost of turbo-generator units used for auxiliary power is included, because the boilers and the balance of the station equipment are common to both steam and electrically driven auxiliary systems. No allowance has been made for space occupied by electrical auxiliary equipment because it would be approximately the same for either type of drive; however, the flexibility of electric control equipment enables it to use space that otherwise might be wasted. In this particular case, the main auxiliary transformers and high voltage switching apparatus are installed out of doors.

Items in Table II exhibiting the greatest possibilities for saving are the control equipment and cables for motors. It seems apparent, however, that a radical reduction in the investment cost of the complete station will not result even from major modifications to the electrical part of an auxiliary system, but rather will have to come from a series of small savings. Some of the possibilities of making these small changes are brought out in the discussions which follow.

### Electric Auxiliary Power Supply

A review of station designs with respect to the source of electric power for auxiliaries shows quite a variety of arrangements, all of which are modifications of two fundamental systems; (1) power from main bus, or (2) power from a separate generator. The advantages and disadvantages of the principal modifications of these two fundamental systems are covered completely in the National Electric Light Association *Publication 088*, April 1930, and will not be repeated here.

It is interesting to note a considerable trend back to the original system of supplying auxiliary power from the main bus after passing through a cycle of house turbines and shaft generators. The system of taking auxiliary power from the generator leads ahead of the oil circuit breaker is virtually the same as taking the auxiliary power direct from the main bus, and both are subject to the same criticism of being affected by bus voltage fluctuations unless the station has been designed to minimize them. In many instances, however, operating experiences appear to justify the use of these simpler and more efficient systems in large stations which form part of extensive interconnected networks.

Of the two methods mentioned, that of taking power from transformers connected to the generator leads is the least expensive because it eliminates the need for auxiliary high voltage transformer oil circuit breakers. The disadvantages of this scheme are substantially the same as for an auxiliary shaft generator except that the shaft generator of course is free from main bus voltage disturbances. Both are affected if the turbine overspeeds, but improvements in governors and the increasing use of generator voltage regulators for system stability purposes tend to minimize troubles of this sort.

If an electric auxiliary system is to be used in an isolated generating station, a more elaborate power supply obviously will be required. This type of station also will necessitate more steam driven reserve auxiliaries for starting-up purposes than now are considered necessary for a station forming part of a large interconnected group.

Although in some stations house turbine-generators have been employed, their economical use appears to be confined to stations using d-c. adjustable-speed motors or where exhaust steam is used for purposes other than for feed water heating. Many engineers feel that a house turbine is justified as a reserve to the other power sources and for starting-up purposes. The type of turbine-generator that can be started up almost instantly from a remote point appears well adapted for this purpose when local conditions justify its use. For all large stations, however, the unit system of supply appears justified, whether it be from house turbines, shaft generators, bus transformers, or transformers on generator leads. As already mentioned, the chief advantages of the unit system are greater reliability and lower interrupting duty on the auxiliary power control equipment.

## ELECTRIC AUXILIARY POWER DISTRIBUTION

Selection of the voltage for an electric auxiliary power distribution system usually is determined by the standard motor voltages available, together with a study of the over-all cost of motors, cable and control equipment. In many of the earlier stations, cable runs were relatively long and the interrupting duty on the control apparatus relatively light, with the result that motors of 50 hp. and more, usually were operated at 2,200 volts. However, with the present trend toward larger stations and consequent greater concentration of auxiliary power, the cost of control equipment has become a large item of the total auxiliary system cost. The 1926 report of the A.I.E.E. power generation committee pointed out this condition and suggested that a study be made of the possibilities of using a 440-volt auxiliary system with carbon air circuit breakers for control. It is interesting to note that a 460-volt system of this type was adopted for the Gould Street station at Baltimore as a result of a thorough study of investment costs and performance of motors and control. This station is designed for four 36,000-kw. units.

In larger stations with units of 50,000 kw. and upwards, two or more auxiliary distribution voltages usually are required; those commonly used are 2,300 and 460 volts, respectively, although in some stations 550 volts is being used in preference to 460 volts. In many instances an appreciable saving can be made in the over-all cost of motors, control equipment, and cable, by extending the size range of the low voltage motors up to 100 hp. or more, and establishing low voltage power distribution groups central to the group of motors fed by the distribution point.

Sometimes a further saving can be made in the auxiliary power switching and control equipment by diversified grouping of duplicate unit auxiliaries. For instance, half of the auxiliaries required for one boiler may be supplied from one bus section, and the other half from another bus section. This not only provides a more reliable power supply, but eliminates the need for double buses, since it is possible usually for maintenance purposes to isolate at least one-half of boiler auxiliaries during off-peak conditions.

## AUXILIARY MOTORS AND CONTROL

If the present high investment cost of auxiliary motors and control apparatus is to be reduced, every auxiliary drive application calling for variable or adjustable speed motors must be investigated and justified by an appreciable saving in over-all costs. In addition to the high investment cost, the use of variable or adjustable speed motors increases maintenance costs and space requirements and to some extent reduces the reliability of the drive.

A review of motor applications for recent large stations indicates a decided trend toward the use of more squirrel-cage and less slip-ring motors. Machinery designers are being attracted by the simplicity of the full voltage starting possibilities of squirrel-cage motors, and in many cases have withdrawn entirely their demands for slip-ring motors merely for smooth starting. Also some of the equipment which formerly required variable speed drive now is being made for constant speed operation with the exception of boiler feed pumps for high pressure boilers. Station designers too apparently are becoming more willing to give up in favor of the reduced investment and maintenance costs made possible through the use of the squirrel-cage motor, any small gains in plant efficiency obtained by variable speed drives.

In regard to motor control apparatus, considerable progress has been made by manufacturers in supplying self-contained motor control groups completely fabricated at the factory. In many cases where the field labor costs are high, a substantial saving can be made by using these factory fabricated groups. An appreciable saving also often can be made in conduit work by using armored cable installed in metal troughs or large pipes indoors, and by using "parkway" cable for outdoor installations. In the middle west during the past few years this method of handling cables has given satisfactory results.

## SUMMARY

The chief advantages of electric drive over steam drive for station auxiliaries are briefly:

1. It facilitates more efficient station design by permitting all of the steam required for feed water heating to be taken from the main turbine by stage bleeding.
2. It may be approximately twice as efficient in terms of B.t.u. per kw-hr. as steam drive depending upon the amount of maintenance received by the auxiliary turbines.
3. It is uniformly efficient, since lack of maintenance does not affect materially the efficiency of electrical equipment, although it may reduce the reliability of the equipment somewhat.
4. It requires less maintenance.
5. It is simpler to operate.
6. It improves the physical design and operation of a station by reducing the amount of auxiliary piping required, particularly in the basement.

Some of the possible methods introduced for reducing the cost of an electrical auxiliary system are:

1. Obtain auxiliary power supply from transformers connected to the main generator leads ahead of the generator oil circuit breakers, and reserve supply from main bus if reliable interconnections are provided with other stations and station bus is protected by reactors or their equivalent.
2. Establish both high and low voltage auxiliary power distribution groups central to location of auxiliaries instead of in electrical bay, to reduce length of cable and conduit runs.
3. Increase the horsepower range of low voltage motors in view of relatively high cost of high voltage control equipment.
4. Diversify feeds to all duplicate auxiliaries where possible, thereby permitting simpler switching layout for adequate maintenance.
5. Use squirrel cage motors and full voltage starting equipment wherever possible even if at the sacrifice of a small percentage in station efficiency.
6. Use factory fabricated control equipment wherever possible.
7. Use armored cables grouped in metal troughs or large pipes for indoor and "parkway" cable for outdoor installations.

# How About the Human Side of It?

**With sympathetic attention and the direction of modern scientific methods toward achieving a solution of existing problems in human relationships, an ideal civilization is foreseen. This is the sixth article in The Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"**

By
ROBERT D. KOHN
President, The American Institute of Architects

THE MATERIAL achievements of engineering and science during the past half-century indeed are an indication of the wonderful possibilities of the trained mind. But that same mind has not distinguished itself by meeting other problems that have grown even more complex in this same period. The benefits that men have received from science are fairly well known. Why try to make a list of them? Such a process appears academic. Is it not likely to lull us into a sleepy sense of repletion, as if the job were well done and, having dined on succulent self-praise, rest were now due? Or worse still, the pride of achievement actually may blind us to the important problem which science has not tackled at all. The present only-too-evident maladjustment (and indeed the misery from which some part of the world always suffers) is in no small measure an indication of a whole series of such vital problems.

It seems that the very real achievements of science and engineering fail of their effect because the human side of the world's problems has been neglected. We have been absorbed in *things*. We have neglected to notice the effect which men absorbed in things have upon other men absorbed in things. We have been proud, for instance, of what engineering has done to annihilate space. Transportation, telegraph, telephone, and the press bring men from the ends of the earth into a new and closer relationship with each other. But we have done practically nothing to develop a technique of human relations to meet the new problems brought about by those closer relationships.

The wonderful qualities of insight and patience, and indeed the genius that has been applied to the material accomplishments of modern times, now must be turned to a much more difficult job. The results of these discoveries must be turned to a more worth-while, a more comprehensive use. Scientists and engineers (and all of the rest of us for that matter) must now concentrate on the study of the relations of man to man, of group to group, and of nation to nation. We must find a way to understand the interrelation and the interdependence upon each other of men within each function of modern life, and the interdependence of function upon function. When these relationships are better understood they will become clarified, and then be more just. And the distribution of the products of modern methods and the benefits thereof (material as well as spiritual) then will be better adjusted, because of necessity that distribution will be based upon a recognition of the essential nature of the contribution that each group makes to the needs of the whole. And a whole world of latent talents will be evoked during this process.

By far the greatest benefits are still to be conferred on the world by the scientific mind and by engineering skill. They will produce in the future still greater inventions. The physical sufferings of mankind will be relieved by further beneficent discoveries of medicine and advances in surgery. But my hope for the future lies in the belief that we are about to shift the direction of our efforts because we have realized that progress lies in another direction. Doubtless the work in study and laboratory should go on, but the leaders of research and the forward-looking men in all the skilled vocations now must turn to a new leadership. It is their duty and their privilege to direct a study of the much more difficult problems in the neglected field of human relations, and these are not problems that can be solved by the few working alone in laboratories. It is a job for the many, out in the open with the whole world as a field of action. There is a new art to be created, superimposed upon material science, and next to which in complexity modern science is simple. An art it will be because it must develop a sensitiveness to the infinite variations, to the differences in values of personalities, and each such perception will have to be interpreted by other personalities.

The painful inefficiency and injustice of our present civilization shows us that this is the great task. Some say that the essence of this task is the basis of all of religion. Others believe that it is the spiritual background on which a new democracy is to be built. Whatever its name, it is a job that we must tackle, for we live in an age of idiotic contrasts. Part of the world is starving with the food bins elsewhere bursting with a surplus of food. The rest of the world is spiritually starving because of a plethora of the thousand-and-one material blessings. I am not interested now in a review of the scientific skill that has produced these things. I want to see it apply itself to working out a new vision of human relations.

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**Editor's Note:** Pursuant to the invitation of The Engineering Foundation, the editors will be happy to receive comments, suggestions, criticisms, or discussions pertaining to this or the other articles in this series.

# A Brief Review of Contemporary Dielectric Research

SUPPLEMENTING the annual report of the chairman of the committee on electrical insulation, division of engineering and industrial research, National Research Council, which appeared under the title "The Trend in Dielectric Research" on p. 967-70 of the December 1931 issue of ELECTRICAL ENGINEERING, a résumé of technical and scientific papers presented at that committee's fourth annual meeting and conference held recently at Harvard University is presented in the four articles which follow. Each article is based upon the papers presented at one of the four technical sessions of the conference, each session dealing with one particular phase of insulation research.

In the first article F. M. Clark has digested and interpreted the contents of the papers presented at the session sponsored by the subcommittee on chemistry, of which he is chairman. The other three articles contain brief abstracts of papers presented at the remaining three sessions for the preparation of which the coöperation of J. B. Whitehead, chairman of the committee, and R. W. Atkinson of the General Cable Corporation, Perth Amboy, N. J. is acknowledged.

## I—Chemical Research in Insulating Materials

By
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INSULATING MATERIALS of the type at present being used in electrical design are difficult to interpret from the standpoint of fundamental characteristics and behavior, not only because of their underlying complexities, but also to a large degree because of their lack of purity. As yet satisfactory methods for gaging the chemical purity of such materials have not been developed despite the fact that their electrical properties depend principally upon the presence or absence of electrolytic impurities. Insulation tests in use generally are electrical in nature; nevertheless their exact relationship to the impurities and chemical behavior of the insulation under test is largely a matter of speculation, and based but little upon experimentally determined facts.

A striking example of the effect of impurities on dielectric strength is the fact that reducing the inorganic ash content of insulation by washing results in a marked improvement in its insulation resistance. About 70 per cent of the ash content of cotton consists of water-soluble sodium and potassium salts; by removing these a 50- to 100-fold increase in the insulation resistance is obtained. Of commercial importance is the fact that washings with distilled water give lower insulation resistance than similar washings with ordinary tap water which usually contains salts of calcium and magnesium. Apparently an ionic interchange is brought about between the alkaline earth salts of the wash water and the inorganic materials of the cotton. In calcium sulphate washings, that portion of the sulphate content of the cotton not associated with alkaline salts remains remarkably constant regardless of changes in the calcium content. With magnesium sulphate washings, the sulphate content decreases due to the greater solubility of the magnesium sulphate formed by the ionic interchange.

### MOLECULAR STRUCTURE OF DIELECTRICS

From such data it may be assumed that the electrical properties of commercial dielectrics depend to a large extent upon their physical structure. Conduction is not due to as great an extent to moisture condensed on the outer surface as to the presence of ionizable salts and moisture within the material itself. Studies on rubber and its purification have served to support this view. Of considerable importance therefore is that proper attention be given to the structural arrangements of the dielectric before attempting to build a superstructure of dielectric theory.

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[1] Based upon the following papers presented under the direction of the subcommittee on chemistry of the committee on electrical insulation, division of industrial research, National Research Council, during the committee's fourth annual meeting at Harvard University, Cambridge, Mass., Nov. 13-14, 1931:

1. Dielectric Constant and Molecular Interaction, by F. G. Keyes, Massachusetts Institute of Technology.
2. The Structure and Electrical Behavior of Insulating Materials, by J. W. Williams, University of Wisconsin.
3. Molecular Structure and Valence, by J. C. Slater, Massachusetts Institute of Technology.
4. The Influence of the Ash Constituents of Cotton on Its Electrical Properties, by A. C. Walker, Bell Telephone Laboratories.

If atoms and molecules are conceived as being made up of positively and negatively charged particles, some structures evidently will be in good electrical balance, in the sense that the center of the electrical effect of the positive and negative charges will coincide perfectly. When placed in an electric field, such complex structures will polarize because the electrical center of the positive and the negative charges will be pulled out of coincidence. This change produces an induced polarity which, if independent of the manner in which the molecule is oriented, would be representative of the simplest dielectric behavior of gases. Peculiarities in the chemical constitution of the molecule, however, may bring about a disposition of atoms such as to give the molecule a permanent electrical moment in addition to an induced moment; in this case the dielectric constant would be expected to be greater. The orientation of fixed dipoles tending toward alinement parallel to the direction of the field would be expected to be interfered with by molecular collision; since such collisions are a function of the temperature, the result at infinite temperature would eliminate the contribution to polarization through the permanent moment. This theory has been remarkably successful and has stimulated an enormous amount of interest in dielectric behavior. Its extension by Debye and others has been made to account for anomalous dispersion at radio frequency and the absorption of energy in solids.

The extension of the molecular dielectric constant theory to highly compressed gases and liquids offers serious difficulties. To date measurements have been obtained at the Massachusetts Institute of Technology for carbon dioxide, ammonia, methane, and hydrogen. The results for carbon dioxide are typical of what may be expected of the dielectric behavior of a non-polar molecule or one having a non-permanent moment. A non-polar gas should possess a polarization independent of temperature; this is true of both carbon dioxide and methane. With carbon dioxide, the polarizability when extended to the region of liquidity under pressure increases only slightly with increased density. With ammonia, however, the increase in polarizability with density is more marked.

Molecular formation is based upon the attraction of constituent atomic electrons, and the valence bond giving atomic union is a resultant of electronic motion. As suggested by Lewis and confirmed by wave mechanics, homopolar bonds result from shared electrons. Electrons are considered to possess a spinning motion, and a chemical bond results from the mutual attraction of oppositely spinning electrons. Most of the electrons in an atom, however, are bound into closed shells with their spins neutralized. Thus only those electrons with unpaired spins can participate in the valence bond. The chemically inert properties of the helium family of elements is so explained. By the same reasoning, oxygen with its two parallel spinning electrons, a condition preventing mutual neutralization or bonding, offers an opportunity for multiple combination or double valence manifestation. The electrons, however, have a definite spatial arrangement and form bonds at particular angular relations to each other. In carbon, this characteristic results in chemical bond along the axes of a regular tetrahedron; in oxygen and in nitrogen, the bonds are respectively at right angles.

## BEHAVIOR OF MOLECULAR GROUPS MUST BE CONSIDERED

In commercial dielectrics, however, attention cannot be confined solely to the structure of individual molecules. To explain electrical conduction and other physical properties, consideration must be given to the behavior of the molecular *groups* which are influenced not only by simple molecular forces but, in addition, by those forces resulting in molecular *aggregation* and the formation of the massive material. Physical studies on cellulose, rubber, and other commonly occurring insulations indicate the presence of primary valence chains rather than aggregate formation by association through secondary valence forces. Primary valence chains are formed by polymerization or condensation reactions; their regular or random arrangement depends upon the number and spatial arrangement of the reacting group present in the elementary molecules. Substances possessing regular arrangements are known to be anisotropic while those having a random arrangement show the same physical characteristics in all directions. In the complicated system of wood, different conductivities are observed in different directions, but probably for a different reason. A number of regularly arranged cellulose macro-molecules are bound together to mi-cells which in turn probably are held together by amorphous cementing materials. The conducting paths in wood are between the mi-cells rather than between the macro-molecules. X-ray diffraction studies have contributed largely to the present study of these substances of high molecular weight.

To account for absorption and energy loss in dielectrics, the presence of free electrons, free and adsorbed ions, and dipoles has been speculated. The ability of dipole molecules to absorb enough energy to attempt to follow the alternation of the applied electrical field has been the subject of considerable discussion. It may well be doubted, however, that the orientation of dipole molecules can explain the energy loss in the molecular aggregates constituting the usual commercial insulation. The macro-molecules may be compared to long fibers, fixed in position and with but little tendency to follow the applied electrical field, even though they contain many polar linkings and groups. It is possible to conceive, however, that polar atoms or groups of atoms in such molecular aggregates may be displaced from their position of equilibrium by an electric field, thus giving rise to an absorption of energy. Because of the nature of the medium, characterized as it is by high inner friction, the motion of these oscillations will be damped strongly. Therefore, a displacement of the group lagging behind the applied electric field will result provided its period is such that the moments of the groups may revert to practically their normal positions between alternations; an absorption of energy then will result. This behavior may constitute a factor which cannot be neglected.

# II—Properties of Materials Probed in Dielectric Research

PROCEEDINGS of the second session of the insulation conference held recently at Harvard University (see footnote) are reviewed here. Like the preceding session under the guidance of the subcommittee on chemistry, this general session was featured by a distinct scientific atmosphere. Several papers were presented dealing with the electrical properties of important types of simple and complex dielectric materials as related to their availability as insulators.

Results of dielectric studies on vulcanized rubber, containing from 2 to 28 per cent sulphur within the temperature range of from 30 to 100 deg. cent. and within the frequency range of 60 to 2,000,000 cycles, were presented by D. W. Kitchin (A'29). More extended data on the well known anomalous dispersion and absorption of rubber sulphur compounds indicated that the theory of dipole orientation frequently evoked in this connection requires some modification. For example, the 600-cycle curve of dielectric constant *versus* percentage of combined sulphur shows no maximum, but rises steadily. Apparently the agents responsible for the anomalous electrical properties are present at any temperature, but their response to the field depends upon the physical state of the material. In tests on samples of high sulphur content, an increase in dielectric constant with temperature was observed. This is attributed to a polarization due to dielectric absorption, caused by particles having a wide range of relaxation times.

A series of studies on the dielectric behavior of solutions of cellulose derivatives in butyl acetate for the frequency range from 1x10$^5$ to 25x10$^5$ cycles was reported by J. B. Miles, Jr. For low cellulose concentration, the power factor and loss were shown to be accounted for completely by conductivity. This did not hold true for the higher concentrations, however, and it is suggested that the additional loss under those conditions is due to dipole orientation. Agreement with Debye's theory is lacking, though, and internal or molecular viscosity is suggested as a possible cause.

In an interesting speculative paper E. J. Murphy extended his proposal of last year, that dielectric absorption, or as he calls it "residual polarization" in certain dielectrics, is due to the presence of internal surfaces upon which ions may be adsorbed. The residual polarization is formed by the redistribution of the ions in an electric field; with increasing field, some of the ions may be separated from the surfaces. This would result in a decreasing dielectric constant and an increasing conductivity with increasing field intensity, the latter effect having been observed frequently. The author supported his theory by the results of some experiments with fine powders; in these tests both types of variation were in evidence.

Further data on the behavior of highly pure hydrocarbon liquids were presented in a paper by L. A. Welo who reported studies on normal decane, dimethyl octane, and on transformer oil. The liquids were studied through a series of successive distillations and cycles especially designed to remove moisture, air, and suspended matter not only from the liquids, but from the measuring system as well. In all cases, low conductivities (of the order of $10^{-18}$ mhos) were reached; the suggestion was made that the conductivities of all hydrocarbons including oils may be reduced to about this value, and that little if any variation of conductivity with structure is to be expected. When the 60-cycle power factors of these purified liquids were measured, losses about $10^6$ times those computed from the conductivity were observed, indicating a large initial absorption or conductivity even in these purified liquids. The obvious explanation for this is that the application of continuous potential difference sweeps out a large number of ions which are active in causing dielectric loss in an alternating field, a picture which is supported by the saturation current-voltage characteristic of the conductivity measurements.

Measurements of irregularities in the conduction current of insulators subjected to constant voltage were reported by F. E. Haworth and R. M. Bozorth. These fluctuations or "noise" were observed by amplification as in the Schrott effect. It is indicated that ions or electrons impinge upon the electrodes in groups of increasing amount depending upon the field strength. The results support the idea that small conducting canals are created in the dielectric at field values considerably below that of breakdown and in increasing number as the breakdown value is approached; sudden discharges traverse the canals, thereby causing the current irregularities. However, the proportion of total current represented by these canal discharges is relatively small.

A paper presented by J. C. Balsbaugh (A'23) and P. H. Moon (M'29) described (1) a precision bridge for measuring the power factor of small oil samples, (2) ac-

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Abstracted from papers presented at the second session of the fourth annual conference of the committee on electrical insulation, division of engineering and industrial research, National Research Council, held at Harvard University, Cambridge, Mass., Nov. 13-14, 1931.

curate adjustable air capacitors, and (3) oil cells to be used therewith. Further refinements were reported in electrostatic screening and in the electrical balance between guard ring and measuring electrode, points emphasized in the development of the Johns Hopkins bridges, with the result of a still further increase in the sensitivity available in bridges of the Schering type. Although no tests on the oils were reported, it is indicated that a sensitivity of better than $+$ or $-$ $10^{-6}$ in the value of loss-angle will be available; on account of the better control possible in the use of small samples, this should permit further refinements in such measurements.

# III—Physical Theories of Dielectric Behavior

IN THE session of the Harvard University insulation conference (see footnote) held under the auspices of the subcommittee on physics, a series of five papers bearing on present physical theories of dielectric behavior was presented. In the first of these, W. F. G. Swann drew a series of analogies amongst the accepted mathematical developments of the theories of steady currents in conducting media, electric induction in non-conducting media, and magnetic conduction in magnetic media. Formal expressions for the fundamental phenomena in these three fields are known to be quite similar. It was shown, however, that there are certain aspects imposed by the restriction to constancy of specific resistance, constancy of permeability, and similar factors, and also by the nature of the mathematical solutions, which raise some question as to the complete accuracy of many accepted relationships. Notably, it is shown that in the general case of simultaneous electric and magnetic fields, it is possible to have at a surface of separation between two media, physical conditions which are not consistent with the usual assumptions made in this case.

As is well known, attempts frequently have been made to draw direct analogy between the properties of dielectrics and those of ferromagnetic materials. In discussing this question, H. Müller pointed out that the parallelism between Langevin's theory of paramagnetism and Debye's theory of polar molecules, suggests the possibility of finding insulators with dielectric properties analogous to the magnetic properties of a ferromagnetic substance. He concludes that such insulators may exist if (1) the substance contains a large number of polar molecules and the temperature is below the critical Curie value, and (2) the polar molecules are able to rotate without association. In support of these assumptions, measurements of the Kerr effect in Rochelle salts were reported.

A series of direct measurements of the relaxation time of abietic acid within the temperature range from 10 to 50 deg. cent. were reported by J. B. Whitehead (F'12) with corresponding measurements of dielectric loss. The method of analyzing dielectric losses which permits the separation of components (reported by A. Banos, Jr. later in the same session) was utilized for comparing the experimental behavior of abietic acid with the expressions proposed in the Debye theory of polar molecules, and with those of the Maxwell theory of dielectric absorption. It was shown that within the temperature range mentioned, the relaxation time is not continuous and that if polar molecules are involved, at least two types are present. The results in general, indicate a behavior in resin more in accord with the Maxwell theory of dielectric absorption, with progressive changes in conductivity and in viscosity accounting for the observed changes in dielectric loss. On the other hand, the experimentally observed change in dielectric constant apparently is not accounted for by either theory.

An interesting series of studies on the oxidation of insulating oil was presented by H. H. Race (A'24). A certain commercial oil was separated into nine samples; these were heated in contact with air at different temperatures for different lengths of time under which conditions studies were made of a number of properties such as conductivity, dielectric loss, spreadability on water, acid number, and viscosity. The results on oxidation were discussed from the standpoint of Debye's theory of polar particles, with conclusion that the number of the particles varies rather than their size. Other studies of the correlation of various properties also were given, with the conclusion that the spreadability test in conjunction with the variation with frequency of dielectric loss under oxidation are the most promising methods for studying progressive changes in insulating oils.

Detailed results of an analytical study of the method for utilizing continuous potential charge and discharge currents observed by the amplifier oscillograph for the prediction of dielectric behavior under alternating stress, were reported by A. Banos, Jr. It was shown that if the portions of these oscillograms for an initial time interval corresponding to the period of the alternating cycle be employed, the current variation may be expressed as the sum of three terms, each containing a negative exponential of the time. This expression, when substituted in von Schweidler's equations, permits the computation of dielectric losses which agree almost exactly with actual measurements. The analytical study with accompanying curves and measurements of loss, power factor, and capacitance, show the reliability and accuracy of the method.

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Abstracted from papers presented at the third session of the fourth annual conference of the committee on electrical insulation, division of engineering and industrial research, National Research Council, held at Harvard University, Cambridge, Mass., Nov. 13-14, 1931. This session was sponsored by the subcommittee on physics.

# IV—Dielectric Research Presages Cable Improvement

THE FINAL SESSION of the insulation conference held recently at Harvard University (see footnote) was devoted more to the practical engineering application of dielectric materials. Ten papers were presented, all of which are reviewed briefly.

In a paper entitled "The Electrical Properties of Impregnated Cable Paper and of Ionized Gas Films," C. L. Dawes (M'15) presented the results of an extended series of dielectric loss measurements in impregnated paper as related to voltage, frequency, and temperature variation. Both sections of cable and laboratory samples with air layers were studied. Several empirical laws were reported, notably for the change in the type of variation with temperature and for the nature of the loss caused by the presence of "ionization" films. Studies such as this involving as it does investigations into the effects of the characteristics of a dielectric's component parts upon its behavior as a whole, have come about from a recognition of the structural nonhomogeneity of dielectrics and have had an important bearing upon the recent great improvements in commercial products.

The apparent presence of an appreciable power factor (of the order of $10^{-5}$) in the air capacitors such as those used in dielectric loss measurements, was brought out by J. C. Balsbaugh (A'23) and P. H. Moon (M'29); the importance of making allowance for this in a-c. bridge measurements using such capacitors was emphasized. This condition is attributed to gas, either adsorbed in the electrode surfaces or forming layers thereon, a belief supported by changes in power factor which took place when the air pressure within the capacitor was varied. Influence of variations in the electrode material, and of different types of surface layers of the same material also were studied. In the discussion, two speakers, one of whom was from the U.S. Bureau of Standards, reported experiments on this subject; in neither case was evidence of the presence of power factor in capacitors discovered.

Development of the sensitive measuring equipment used in this study of residual losses in air condensers came about as a direct consequence of the improvements in dielectrics which resulted in requests from utility engineers and manufacturers for equipment capable of making adequate measurement as improvements are continued further. The more obvious imperfections of air condensers that have caused some trouble to earlier investigators were fully eliminated; present investigations, requiring as they do the use of a condenser as a primary standard, not only involve precise electrical measurements, but also necessitate a fundamental study of both the condenser and its electric field.

In two papers, J. B. Whitehead (F'12) reported further experiments at Johns Hopkins University on the properties of impregnated paper used in high voltage cables. The first one described how, by measurements with the amplifier oscillograph of the short time d-c. conductivity and absorption of the oil and the paper separately and in combination, it is possible to follow the separate influences of each on the behavior of the final product very much more closely than heretofore. New evidence was presented as to the correlation between the physical characteristics of the oil and the separate components of the total loss in impregnated paper. The method used was an accelerated life study, samples being tested by the application of successively increasing voltages, starting with 400 volts per mil. A highly refined light oil showed a life greatly in excess of most of the other oils studied; second came an oil of naphthene base; thereafter, in a group in which the variations in life were not great, came a number of oils commonly used in cable manufacture. In the discussion of these results, it was indicated that while the electrical characteristics and the life of the light oil were of high order, oils of this type were not suitable for practical use because of their rapid deterioration, both in the process of manufacture and under those conditions pertaining to cable operation which are not present in laboratory studies. Another interesting result was that although the naphthene base oil had relatively long life, its power factor and loss were so high as to render its use in cables prohibitive. The results in general emphasize the fact that while oils of highly desirable characteristics and long life may be obtained, it may be impossible to use them practically, because of the limitations imposed by the handling and operation of cables in long lengths.

The second of these two papers is a part of a series involving a study of the electrical characteristics of condensers made with commercial or semi-commercial materials and prepared under accurate laboratory control of conditions varied according to a prearranged schedule. The resulting data are adding materially to existing comprehensions of dielectric characteristics.

Interesting results on the influence of high oil pressure upon the electrical endurance of cables were reported by J. A. Scott (A'25). Experiments were made both on cables and on sheet paper immersed in oil. By the application of a pressure of 80 lb. per sq. in. above atmosphere, the dielectric strength of the cable was found to be doubled, with a similar though lesser increase observed in the sheet paper experiments. The effect of pressure on the strength of cable insulation containing voids or bubbles has been recognized fully and studied extensively, but the meagerness of earlier data on the subject discussed by the author adds to the importance of his contributions. Full development of

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**Abstracted from papers presented at the fourth session of the fourth annual conference of the committee on electrical insulation, division of engineering and industrial research, National Research Council, held at Harvard University, Cambridge, Mass., Nov. 13-14, 1931.**

the laws governing the effect of pressure on dielectric properties is important both from the standpoint of dielectric theory and from that of practical application.

A discussion of the voltage-time characteristics of saturated paper insulation next was presented by R. W. Atkinson (F'28) accompanied by new data based upon extensive experiments on the breakdown life of cable samples under impulse and accelerated voltage step experiments. The results show clearly the limitation of the commonly-used straight hyperbolic voltage-time relation, and the wide error which may result. The experiments reported indicate that within the range of from 5 min. to 500 hr., the voltage-time relation is more closely represented by a formula in which the breakdown gradient is made up of two terms: (1) a constant term representing the voltage which the insulation will stand for indefinite time, and (2) another term inversely proportional to a root of time varying from 1.5 to 4. Especially interesting were the studies of breakdown under impulse voltages, these indicating values very much less than those computed from the law just stated. Indications are clear therefore that formulas of this type are suitable only for studies on the same type of material and within a range of time in which they are known to be applicable. The obvious suggestion is that the impulse breakdowns are perhaps of straight electrical character, whereas the breakdowns under sustained voltage involve other factors such as perhaps local liberation of internal heat. Other data indicate that high-density papers have higher dielectric strength than lower-density papers within the time range mentioned. Another striking fact is that great variation in the shape and slope of the voltage-time curves are found with different types of impregnating material; thus the curves for different compounds may cross not only once but even twice. These data help to indicate the inaccuracy of comparing the qualities of dielectrics without taking into account these variations in the shape of the voltage-time curves.

An extensive series of studies of high voltage cables under operating conditions, involving daily measurements of power factor, loss, and ionization through temperature cycles and at excessive voltages, was reported by R. J. Wiseman (F'27). A feature of this paper was the description of the laboratory arrangement and testing equipment which provided for testing cables carrying heavy current while under voltage stress. The cable ends were sealed and internal oil pressures were measured as were the dielectric losses and the duration of cable life. Based upon an illuminating continuous record of the experiments, the author discussed various factors bearing on cable behavior and the importance of improvement in methods of studying and controlling these factors. Significant data also were given as to bursting stresses to which the lead sheath was subjected by the load cycles imposed.

The deterioration of oils under a-c. corona discharge next was discussed by K. S. Wyatt, in continuation of his work on the deterioration of and wax formation in oils such as used for the impregnation of paper. In the experiments the oil was subjected to corona discharge, the gases formed thereby forcing the oil into a power factor measuring chamber. From the latter, the oil due to its own weight flowed back into the original discharge chamber, thus permitting a circulating action and continuous observation. The results showed a marked increase in the dielectric loss with duration of corona exposure. In the case of a water-white paraffin-base oil, in thirteen hours the power factor increased from 0.4 to 4.1 per cent. The exact nature of the increased loss is under further investigation.

The occurrence of ultraviolet light and X-radiation from gaseous discharges within the body of insulation were topics discussed by E. B. Baker and R. F. James. These types of radiation are thought to be caused by electrons and ions falling through high local stresses before collision with the matter. Experiments were reported showing that the production of such radiation usually is associated with unequal potential distribution in the dielectric, a condition often noted. Importance of the question lies in the possible deterioration of the dielectric structure by the ultraviolet and X-radiation.

Further results of the continuous study of cable performance and quality were outlined by D. W. Roper (F'14) these being carried out on the cable systems and in the laboratories of the Commonwealth Edison Co. (Chicago) and correlated with factory tests. The records of nearly 300 miles of 66-kv. cable and a large amount of 33-kv. three-conductor cable over a number of years are reviewed and a number of important deductions made. Two accelerated life or aging tests are discussed. One of these, involving a test voltage of about twice operating voltage and with cycles of heating and cooling, is much more discriminating and valuable than a test at high voltage and without heating cycles. It gives results consistent with practical cable operation; this correlation with extensive operating experience is suggested as establishing the test as an adequate method of proving the satisfactoriness of any given type of cable to meet standard operating conditions. While the establishment of such a test and its relation to operating performance is an important adjunct to effective future developments, it emphasizes the necessity for the development of a laboratory test to predetermine the stability of an impregnating compound under service conditions, and for a factory test adequate to eliminate sections of cable having local imperfections.

Cables performing perfectly under normally heavy loads were shown to have been those saturated with a tacky impregnating compound which in two cases consisted of a mineral oil and in the other two, compounds containing rosin or rosin oil. Presence of rosin or rosin oil, however, does not necessarily mean that a compound will be satisfactory for fully loaded cables; but all cables having a perfect service record with normally heavy loading for long periods, had a low ionization factor. For lightly loaded cables these same qualities seem desirable, but apparently not as necessary.

# Measuring Core Loss at High Densities

**Modern electrical machines employ flux densities in excess of those previously measurable by routine methods. The refined method now available for densities up to 20,000 gausses therefore is recommended for adoption as standard.**

By
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GREATER ECONOMY and efficiency of electrical apparatus require a better knowledge of the core loss values for magnetic sheet steels at high flux densities than heretofore has been available. The Epstein method adopted as standard by the American Society of Testing Materials is at present the routine method of making core loss measurements at normal densities. However, it is inadequate for measurements at densities above $B = 14{,}000$ gausses, and refinements have now been worked out in the new scheme which make it possible to extend the core loss measurements on sheet steel up to $B = 19{,}000$, and on some sheet steel up to $B = 20{,}000$. Although previously a sine wave of applied voltage has been necessary for accurate measurements, the new method does not require the maintenance of a sine wave of induction in order to obtain a true measure of the maximum flux density.

The over-all accuracy of the measurements obtained by this new method approaches the accuracy of 2 to 3 per cent specified for the standard Epstein apparatus and is well within the accuracy of sampling sheet steel. Because of its accuracy, simplicity, and convenience, this method is recommended for use as the standard method in core loss measurements, so that routine acceptance tests may be extended to the high flux densities met in actual practise.

The testing equipment used for obtaining core loss data at high flux densities consists of an alternator of sufficient capacity, an Epstein testing frame, an ammeter, a frequency meter, an r.m.s. voltmeter, a flux voltmeter, and an astatic reflecting electrodynamic wattmeter, connected as shown in Fig. 1. All of these instruments except the flux voltmeter and the wattmeter are included in the present routine test equipment as described in the A.S.T.M. specifications. The wattmeter, while not a portable instrument, is commonly used in laboratory testing. The flux voltmeter consists essentially of a rectifier and a d-c. voltmeter of the D'Arsonval type, so that the indications are directly proportional to the maximum flux density in the test specimen regardless of the wave shape of the induced voltage.

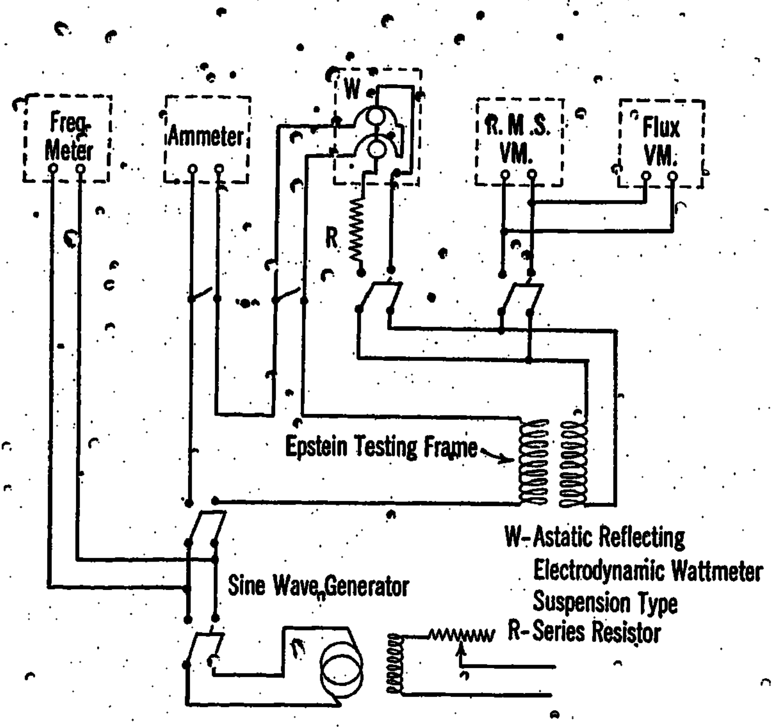

**Fig. 1. Connection diagram of method for core loss testing at high flux densities**

The method previously in use requires that a harmonically varying induction be set up in the test sample by the application of a voltage of sine wave form across the magnetizing coil of the test frame. This method cannot be applied accurately to high density work. The chief difficulty is the large magnetizing force which causes (1) a distortion of the flux wave, (2) a large flux in the test coil and (3) a low power factor.

### DISTORTION OF THE FLUX WAVE

The distortion of the flux wave operates as a source of error in two ways: First, if the maximum flux density $B_m$ is determined by an r.m.s. voltmeter in the secondary circuit according to the well known formula, based on a sine wave voltage, the result will be erroneous. Secondly, it introduces additional losses in the specimen due to high frequency components of the eddy currents. The theory of the method of determining the maximum flux density regardless of its wave shape is based on the following:

1. The maximum alternating flux density is proportional to the arithmetic average value of the induced voltage regardless of the wave form of the voltage.

2. If an alternating voltage rectified without changing the wave shape is impressed on a d-c. voltmeter of the D'Arsonval type, the instrument indications are proportional to the arithmetic average value of the rectified wave which is the same as the arithmetic average of each half cycle of the unrectified a-c. wave.

Measuring the average voltage (*i. e.*, the arithmetic mean value of a half cycle of the voltage wave, corre-

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Based upon "Core Loss Measurements at High Flux Densities" (No. 31-77) presented at the A.I.E.E. North Eastern District meeting, Rochester, N. Y., April 29-May 2, 1931.

sponding to the point of extreme variation of flux in the associated flux wave) instead of the r.m.s. voltage eliminates the previously mentioned error in the measurement of $B_m$ and makes it possible to determine the true maximum value of the flux irrespective of the distortion.

It should be noted that when $B_m$ is correctly determined, the hysteresis component of the core loss also is correct, the error in the measurement being entirely in the eddy current loss. Since the total eddy current loss is in general a much smaller quantity than the hysteresis loss, it is obvious that the correction to the eddy current loss is a correspondingly small percentage of the total loss. The error in the measured loss cannot be eliminated but can be corrected readily by any one of a number of methods. The simplest and most rapid of these is the per cent eddy method, as it requires fewer test data and calculations. The accuracy is well within the limit of measurements and the method therefore especially is recommended for routine testing. In this method, the percentage of eddy current loss for a sine wave of induction is assumed based on data obtained on similar material. The sine wave core loss is calculated by the relation

$$\text{Sine-wave } W/\text{lb.} = \frac{W/\text{lb} \times 100}{h + k\,e}$$

where

$e$ = assumed per cent eddy current loss
$h$ = 100 − $e$ or per cent hysteresis
$k$ = ratio $\left(\frac{E_{r.m.s.}}{E}\right)^2$
$E_{r.m.s.}$ = the r.m.s. value of the induced voltage
$E$ = the average value of the induced voltage

The form factor $k$ can be computed from simultaneous readings of the r.m.s. voltmeter and the flux voltmeter.

The area enclosed by the potential coil of the Epstein test frame necessarily is larger than the sample area. This necessitates a correction for voltage induced by the air flux. At low magnetization values this is negligible, but at high flux densities when the magnetizing force required is large, the correction is appreciable and must be applied as described below.

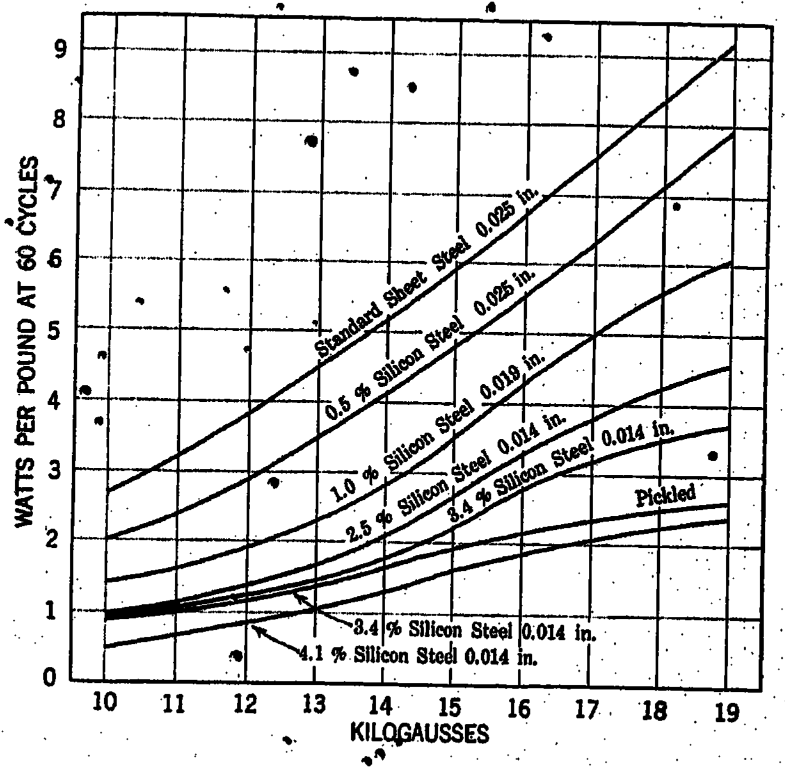


Fig. 2. Core losses of magnetic sheet steels

The total voltage induced in the potential coil is given by the formula

$$E = E_i + E_a$$

where

$E$ = the r.m.s. value of voltage required
$E_i$ = the voltage induced by the flux in the core
$E_a$ = the voltage induced by the flux in the air space

$E_a$ is called the space factor correction voltage. This often amounts to 4 per cent of total voltage at the highest $H$ values, and if ignored would produce a corresponding percentage error in the flux density. Since the voltage $E$ to be maintained always is computed on a sine-wave basis regardless of the form of the induced voltage wave, we have

$$E_i = 4.44\,B\,N\,A\,F\,10^{-8}$$

$$E_a = 4.44\,H\,N\,(a - A)\,F\,10^{-8}, \text{ whence}$$

$$E = 4.44\,N\,F\,10^{-8}\,(B\,A + H\,(a - A))$$

in which

$B$ = maximum flux density in the iron
$N$ = potential coil turns
$A$ = area of test sample in sq. cm.
$F$ = test frequency in cycles per sec.
$a$ = area enclosed by potential coil in sq. cm.
$H$ = air flux in gausses. This is equivalent to the magnetizing force in gilberts per cm. For the purpose of computation, the value of $H$ is usually taken from a d-c. magnetization curve of representative material

The low power factor of the circuit emphasizes the small phase angle error inherent in every wattmeter and also requires that an instrument of large current capacity and high sensitivity be used. The desired characteristics are obtained by the use of a suspension type astatic reflecting electrodynamic wattmeter. This instrument by its high sensitivity permits the use of a current coil of few turns of heavy cross-section conductor. It also permits a potential coil of few turns; that is, a very small inductance and a comparatively large resistance.

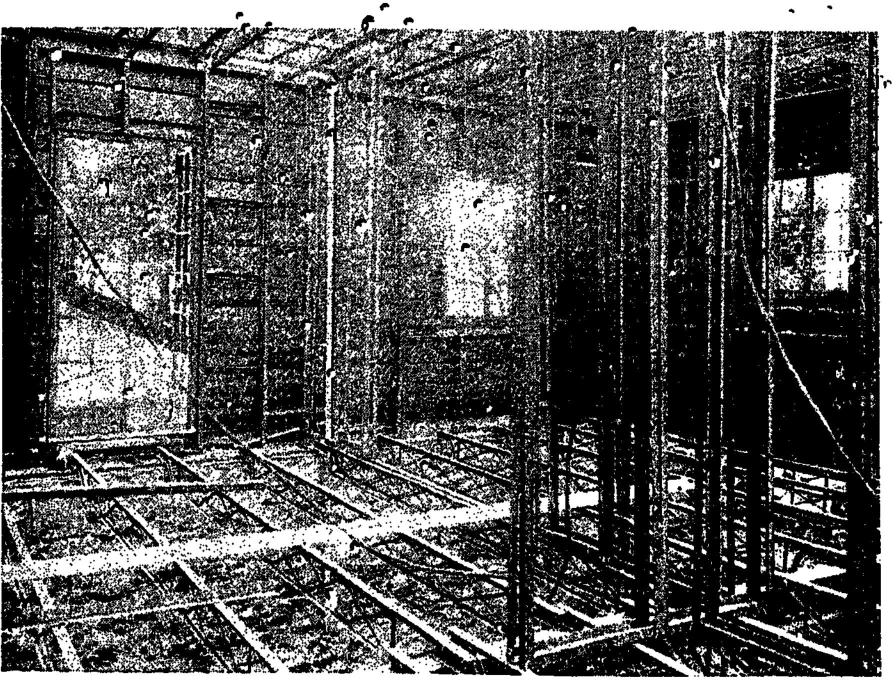
At first it was expected that the non-uniformity of the flux distribution over the length of the sample might be a source of considerable difficulty. Tests, however, have shown that the non-uniformity at high flux densities is no greater than at the moderate densities for which the Epstein apparatus was designed; therefore it was assumed that for the present error from this source could be ignored.

The test procedure is essentially the same as that for testing at normal densities. A 10-kg. sample of 50 x 3 cm. strips is made into four bundles and inserted in the test solenoids with paper separators at the joints as described in the A.S.T.M. specifications. The steps are then carried out as previously described.

Some illustrative core loss curves obtained by the routine method are given in Fig. 2. The characteristics of these curves at high flux densities when compared to those at normal densities show the value of these measurements; the reversal of the silicon steel curves confirms what was theoretically expected but seldom shown. It is interesting also to note the effect of scale on the losses at high flux density as illustrated by the two curves of 3.4 per cent silicon steel; one represents the losses before pickling, and the other, the losses after removing the scale. The benefits of this treatment are shown by the measurements to be obtainable only at high flux densities.

The accuracy of these measurements approximates very closely the accuracy of the Epstein apparatus under the normal test conditions at $B = 10{,}000$. This was demonstrated by tests using both sine and distorted waves at this density. Excellent agreement was found between the sine wave core loss and the corrected losses obtained with distorted waves.

The method described is adaptable to the widely used Epstein equipment, combining all the advantages of simplicity, convenience, expeditiousness, and accuracy of that method. In addition, it may be extended into much higher densities. Therefore it is recommended for use as the standard method for core loss measurements in order that routine acceptance tests may be made at flux densities more nearly equaling the highest working densities of modern machines.



General Elec. Co. Photo.

**Fig. 1. (Above) Interior view of panel type arc welded framing during course of construction**

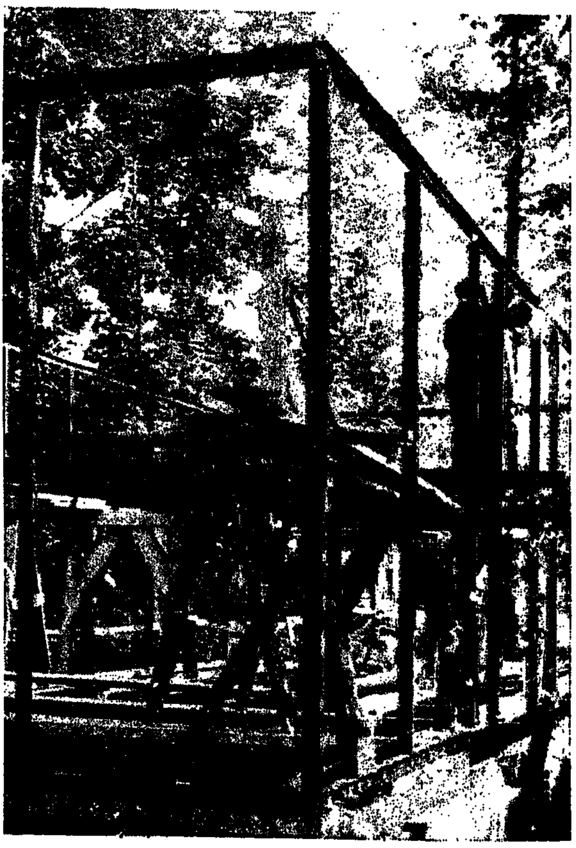


**Fig. 2. (Right) Arc welded house frame being fabricated on the job from standard structural shapes**

Lincoln Elec. Co. Photo.

# Residences with Arc Welded Steel Frames

ARC WELDED steel framing for dwelling houses is representative of some of the recent experiments in modern building construction. Many advantages are claimed for the welded type of construction, among them being: rapidity and noiselessness of construction, flexibility of design, rigidity and solidity, low rate of depreciation, and a lower insurance rate resulting from the fireproof construction which this method makes possible. What is more important is the fact that all of these advantages may be realized without any appreciable increase in cost over older methods of construction.

Two methods of construction are indicated in the two illustrations. These do not represent any freak combination of new materials but embody only tried and proved engineering principles and construction methods already being applied to larger and taller buildings. Interior and exterior appearances of the finished houses are no different from those of similar houses built by older methods, but notwithstanding this the possibility for individuality in the design and layout of arc welded frame dwellings is thought to be greater than that allowed by present construction.

The entire framework including all interior partitions, of the house shown in Fig. 1, was made up of standard sized panel frames previously fabricated in the welding shop. As may be noted, duplicate frames were used throughout, these being tied together with spacers to provide standard wall thickness. Two sizes of panels were used: namely, 2 x 9 ft., in wall sections without windows or doors, and 6 x 9 ft. for sections including window or door openings. Gable sections were fabricated in the shop, then trucked to the building site and welded to the framework proper.

A somewhat different type of construction is illustrated in Fig. 2; in this case standard steel shapes delivered to the building site like lumber were used throughout without shop fabrication of any kind. Three workmen erected the 10 tons of steel required in this building with no other tools than squares and the usual arc welding equipment.

# Abstracts

## Of Papers to be Presented at the Winter Convention

INTERPRETIVE abstracts of the majority of papers to be presented at the A.I.E.E. winter convention (January 25-29, 1932) are presented herewith, excepting only those papers published in this issue of ELECTRICAL ENGINEERING and those not available for publication at the closing date of this issue. Abstracts of the remainder of winter convention papers are scheduled for publication in the February issue. Members vitally interested and wishing to obtain immediately pamphlet copies of any available papers are requested to use the order form appearing on p. 70 of this issue. In response to popular demand and within its space limitations ELECTRICAL ENGINEERING subsequently may publish certain of these papers, or technical articles based upon them.

### New High Speed Distance Relay With Impedance-Reactance Characteristic

By
S. L. Goldsborough[1]
W. A. Lewis[2]

THE TWO general types of distance relays for isolation of faulty sections of transmission line are impedance relays, operating upon the impedance of the line between the relay and the fault, and reactance relays, operating upon reactance alone. Each of these types has certain advantages as well as certain disadvantages; it is the purpose of this new relay to combine the principal advantages of both types.

The impedance relay is fundamentally more simple, and can be made to operate at a considerably higher speed. However, the presence of accidental arc resistance at the point of short circuit increases the impedance as viewed from the relay, and makes the fault appear more distant than it really is. On the other hand the reactance relay is affected to a less extent by the presence of arc resistance, but in general requires a more complicated structure which does not lend itself readily to obtaining high speed. Furthermore, additional features are required to prevent the operation of this type of relay under normal load conditions. Difficulty is also experienced in making the auxiliary features operate properly in all cases.

Although a relay of this new design can be made to operate as a pure reactance device, it is believed that more satisfactory operation can be obtained by an intermediate characteristic. This modified characteristic permits a relay to be obtained which combines the mechanical simplicity and inherent possibilities of high speed of operation, so desirable where stability is a factor, and the greater independence of the reactance type relay from the effects of fault resistance on the shorter lines. (A.I.E.E. Paper No. 32M1)

### The Theory of Oil Blast Circuit Breakers

By
D. C. Prince[3]

DIRECT experimental proof of the oil blast theory of arc interruption has been assembled. A circuit breaker has been constructed having oil driven between its electrodes at a measurable velocity, and tests show that a correlation exists between the rate of recovery voltage rise and oil velocity. This correlation corresponds to an oil dielectric strength of 55 kv. per 1/10 in. of oil. To determine whether or not this correlation is accidental, relations between voltage and oil velocity and between current and oil velocity have been studied, but correlation does not appear. Impulse tests also have been made on clean and carbonized oils.

Comparative data are available for various methods of forcing the oil blast between the electrodes. It has been found that at the current zero there is a correlation between voltage recovery rates and chamber pressure. This result is surprising since the relation between pressure and oil flow are complicated by the circuit, of passages, back pressure due to oil head and gases generated by the expelled arc.

The laws which govern all variables involved in the design of oil blast circuit breakers are known with the exception of the amount of energy developed by the arc, and even this factor has been observed empirically. Although considerable refinement of the oil blast theory remains to be done, as a whole it rests upon the secure foundation of comprehensive tests and calculations. (A.I.E.E. Paper No. 32-8)

### The Practical Application of the Oil Blast Principle of Circuit Interruption

By
R. M. Spurck[3]

DEVELOPMENTS in theory, calculation, and test results of circuit interruption by means of the oil blast, have placed new tools in the hands of designers, enabling them to construct apparatus of greater efficiency and consistency of performance than heretofore possible. Various applications of these new methods have been made to circuit breakers of all classes and voltages. Circuit breakers equipped with the oil blast device show consistently short arc lengths and unusually short periods of arc duration, even at high rates of recovery voltage rise and over wide ranges of current. The result of this is that contact burning and oil deterioration are minimized and maintenance is greatly reduced. The rapid arc extinction characteristic of the oil blast design makes it admirably suited to breakers requiring high speed of operation.

In most types of circuit breakers, the method of securing the oil blast is by having an auxiliary gap which opens first and by means of the arc formed generates gas to create pressure within the chamber. As the main gap opens, the pressure generated by the auxiliary gap is forcing oil at high velocity through the main gap and down through the contact rod so that the arc products in the main gap are replaced with solid oil of high insulation value which resists puncture by the recovery voltage and at an early current zero prevents further current flow. In a new circuit breaker of very high operating speed the oil blast is obtained, not by the generation of gas in an auxiliary blast but by a piston acting in a cylinder containing oil. **(A.I.E.E. Paper No. 32-9)**

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[1] Westinghouse Elec. & Mfg. Co., Newark, N. J.
[2] Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
[3] General Electric Company, Philadelphia, Pa.

## Recent Developments in Arc Rupturing Devices

By
R. C. Van Sickle[2]
W. M. Leeds[2]

THE EXTINCTION of an a-c. arc by the deion grid method has been very successfully applied during the past two years to the design of an extensive line of arc rupturing devices for oil circuit breakers of all voltage classes. Refinements have been made in the theory of operation of deion grids and in the construction of several types. Field operation and special tests have given much information regarding these devices.

With the deion grid circuit breakers the arc in oil is drawn through a narrow insulated slot open at one end, and magnetically forced into a series of oil pockets. The gas generated can escape only by passing through the arc stream so that the arc is subjected to a continuous turbulent blast of fresh un-ionized gas. A dielectric strength of perhaps twenty times the arc voltage is established within a very few microseconds, and is further increased as deionization continues with the aid of the gas blast.

Laboratory tests have shown that the replacing of plain or quick-break contacts by deion grids reduces the duration of arcing on a 66-kv. circuit to only from 1/4 to 1/7 of the former arcing time, while the arc energy was only from 5 to 10 per cent of the values associated with the old style of contact. Similar results have been observed with circuit breakers for all other classes of service. These results mean great improvement in system stability, reduction in contact depreciation and oil deterioration, and make possible long periods of service without maintenance to the circuit breakers. **(A.I.E.E. Paper No. 32-10)**

## Extinction of A-C. Arcs in Turbulent Gases

By
T. E. Browne, Jr.[2]

IN CIRCUIT breakers employing arcs submerged in liquids such as oil, carbon tetrachloride, or water, the surrounding liquid surface serves both to restrict the arc space and to furnish a gas blast by rapid decomposition under the influence of the high temperature arc. The fiber tube of the common expulsion fuse acts in a similar manner. In the liquid circuit breakers, various devices are available to increase the interaction between arc and liquid, thus aiding in arc extinction.

The results of recent experiments to obtain conclusive evidence of the actual mechanism of such action reveal the following facts:

1. In general the interrupting ability of an a-c. arc is greatly improved by turbulent motion of the arc gases, in a fast circuit this improvement increasing almost in direct proportion to the gas velocity from which the turbulence results.

2. The interrupting ability of a turbulent a-c. arc depends very largely upon the composition of the arc gases, most gases being decidedly superior to air in this respect.

3. The recovery of dielectric strength following a current zero by an a-c. arc subjected to turbulence takes place in two consecutive phases: the first consisting of a very rapid recovery to a substantial value in a few microseconds, and the second of a very much slower further recovery for a much longer period.

4. At least one practical gas blast circuit interrupter, the expulsion fuse, exhibits a volt-time interruption characteristic which clearly indicates the role of gas turbulence in its operation. **(A.I.E.E. Paper No. 32-11)**

## High Voltage Bridge for Measurements of Cables with Grounded Sheaths

By
C. L. Dawes[4]
A. F. Daniel[4]

PRECISION bridge measurements are now in use for measuring the dielectric properties of cables when the current through the dielectric can be conducted directly from the sheath to the measuring apparatus. As a rule, however, these methods cannot be applied to cable with sheaths in electrical contact with ground. There is one method in which bridge measurements are made of all system losses, with and without the test cable connected in the circuit; the difference gives presumably the power loss in the cable dielectric. This method does not give the cable electrical properties (power, power factor, and capacitance) directly, and special precaution must be taken in connecting the cable.

There has been developed a bridge method which does measure directly, and with a high degree of precision, the values of the electrical properties of the test cable even though the sheath of the latter may be grounded. In this method, a four-arm bridge consisting of a standard air condenser and some condenser or cable other than the test cable is first balanced, with the terminal of the galvanometer at the condenser or cable grounded. This balances all system losses to ground. Then the bridge is rebalanced with the test cable connected in circuit. After this last balance, none of the current through the test cable can flow to ground, but must flow through its appropriate bridge arm. The dielectric measurements and also the cable properties thus are read directly from the bridge balance and do not involve correction for system losses. **(A.I.E.E. Paper No. 32-12)**

## A High Sensitivity Power Factor Bridge

By
W. B. Kouwenhoven[5]
A. Banos, Jr.[5]

AN A-C. BRIDGE of high precision has been developed for power factor measurements in an investigation of the properties of cable compounds and papers and of the characteristics of cables that occur after impregnation. The bridge, a modified form of the Schering bridge, possesses several novel features and advantages. The detecting instrument is a moving coil a-c. galvanometer with field excitation supplied from a phase shifting transformer permitting independent ratio and phase-angle balances. A shielded transformer electrostatically isolates the galvanometer from the bridge circuits. This bridge is completely shielded and guarded.

The analytical theory of the resulting mesh connection has been developed in a general manner so that this mathematical treatment may be applied to any similar network. Complete study has been made of the effects upon the balance relation of various sources of error, such as for example, failure to balance guard circuits properly and the presence of leakage resistance between measuring and guard circuits. Experimental verification of the equations has been produced. Power factors of specimens of cable material have been measured ranging from 0.00007 to 0.16 with a maximum variation of ± 0.000005. (A.I.E.E. Paper No. 32-13)

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[4] Harvard University, Cambridge, Mass.

[5] Johns Hopkins University, Baltimore, Md.

## Power Factor Measurement by the Capacitance Bridge

By
R. P. Siskind[4]

SEVERAL types of capacitance bridge for the measurement of both capacitance and power factor of dielectric specimens are in use at the present time. Some of these make a direct comparison between the capacitance under test and a standard capacitance. For accurate power factor measurements upon dielectric specimens at low voltages and audio frequencies, however, a substitution method is generally preferred. Two substitution methods which may be referred to as the "direct" and the "parallel" are commonly employed. With each method, a small change in the phase angle of the arm of the bridge circuit in which the substitution is made occurs. The compensation for this change enters directly into the measurements, and the essential differences between bridges in common use is in the manner of making this adjustment.

A recommended type of capacitance bridge has been developed having the following advantages:

1. All operating controls are at ground potential reducing the effects of hand capacitance to a minimum.
2. The bridge is entirely self-contained except for oscillator, amplifier, and telephone receivers.
3. All parts except the high-potential terminal for the lead to the test specimen are shielded totally.
4. All controls are variable continuously.
5. The bridge may be constructed entirely of standard parts, the shielding excepted. (A.I.E.E. Paper No. 32-14)

## The Photoelectric Recorder

By
C. W. LaPierre[6]

THE MOVING parts of electric indicating instruments may be light in construction and of low torque, thus requiring small energy input from the circuit being measured. When it is desired to record these measurements, however, the moving parts are usually heavier in weight and require higher torque than the corresponding parts of indicating instruments.

A photoelectric recorder has been developed combining all the advantages of the direct-acting recorders with those of the most sensitive indicating instruments. This is accomplished by providing a separately excited recording element to do the actual work of making the records. A sensitive indicating instrument controls the position of the recording element, the only link between these two being a combined optical system and photoelectric circuit. As the only equipment placed on the shaft of the basic or indicating element is a galvanometer mirror, this element may be even more sensitive than the usual indicating instruments with pointers. Through a system of mirrors and photoelectric tubes the position of this mirror controls the position of the recording element which readily may possess as much torque and be as heavy and sturdy as desired without affecting the basic element or measured circuit in any way. In general, anything which can be indicated can be recorded continuously by means of the photoelectric recorder. It is self-compensating for all normal changes in supply voltage, lamp illumination, and pliotron and photoelectric tube characteristics, and is of an extremely high accuracy. (A.I.E.E. Paper No. 32-15)

## Interconnection of Primary Lightning Arrester Ground and Grounded Neutral of the Secondary Main

By
C. F. Harding[7]
C. S. Sprague[7]

VARIOUS possible transformer connections and protective devices on standard 60-cycle overhead power and lighting distribution systems having 4,000-volt four-wire primaries and power and lighting secondary mains have been investigated over a period of years. Considerable information was furnished by an experimental line with an insulated artificial cloud charged to potentials up to 150 kv. by means of a surge generator. Among the conclusions reached are the following:

1. Efficient primary protection upon an overhead distribution system affords a considerable degree of protection to secondaries located below the primaries.
2. A well-grounded secondary neutral wire acts in reducing potentials on adjacent wires.
3. With existing transformer design, the insulation of the secondary winding may be considerably over-stressed by surges having steep wave fronts, without excessive stress on the primary insulation. Such secondary stresses may be relieved by improvements in secondary insulation.
4. Low ground resistances, although desirable in other respects, do not reduce necessarily the initial potentials which may be induced upon the system.
5. A non-inductive load in the consumer's premises reduces the potentials at the service entrance 60 to 70 per cent.
6. Tests have shown that the interconnection of primary lightning arrester ground to the grounded neutral of the secondary main effects a considerable reduction in voltages at the transformer and imposes no extra hazard upon the consumer's wiring. (A.I.E.E. Paper No. 32-16)

## Field Studies of the Protection of Distribution Transformers By Lightning Arresters

By
K. B. McEachron[8]
L. Saxon[9]

A COOPERATIVE field study with portable impulse generator and cathode ray oscillograph was made of the lightning protection of transformers connected to a 4.45-mile, 4,600-volt rural distribution circuit. The tests described were made with the pellet arrester. The results show that:

1. Although the arrester discharge voltage is but a fraction of the strength of the transformer, arrester ground resistances may be high enough not to protect the transformer if the usual connection to ground is employed. This results in either blown fuses or winding failure.
2. Interconnection of the primary arrester ground and secondary neutral gives a high degree of protection to the transformer from surges originating on either primary or secondary, regardless of the arrester ground resistance.

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[6] General Electric Company, Schenectady, N. Y.

[7] Purdue University, Lafayette, Ind.

[8] General Electric Company, Pittsfield, Mass.

[9] Utility Management Corporation, New York, N. Y.

3. With low resistance secondary grounds, such as water pipes, both lightning voltages and power voltages on the consumer's premises will be negligible in value, either with or without the above mentioned interconnection.

4. With interconnection it is believed that the possible hazard between separate grounds which now may exist on the consumer's premises, resulting from high resistance secondary grounds, will be greatly reduced. (A.I.E.E. Paper No. 32-17)

## Protection of Distribution Transformers from Failure Due to Lightning

By
A. M. Opsahl
A. S. Brookes[10]
R. N. Southgate[10]

USUAL methods of connecting arresters for the protection of distribution transformers often are inadequate, resulting in flashover of bushings or windings due to lightning, even though the arrester in itself is capable of protecting the transformer with a large factor of safety. Such flashover may be attributed to the fact that surge current flowing to ground through the ground leads of the arrester gives rise to inductive drop and resistance drop which add to the arrester voltage.

Improved protection of the transformer results from the connection of the arrester ground lead to the secondary circuit. The following methods limit the surge voltage across the bushing approximately to the characteristic crest voltage of the primary arrester, but differ in resulting secondary voltages:

1. Direct connection of a low resistance primary arrester ground to a grounded secondary neutral produces no higher voltages on the customer's service than are experienced when flashover occurs with the present protection schemes.

2. Connection of the primary arrester ground to the secondary neutral through a low voltage arrester gives substantially the same results as with the direct connection.

3. Connection of the primary arrester ground through two low voltage arresters to the secondary outside wires results in increased customer voltage. (A.I.E.E. Paper No. 32-18)

## Studies in Lightning Protection on 4,000-Volt Circuits—III

By
D. W. Roper[11]

FOR A NUMBER of years accurate data regarding the causes of lightning failures on distribution lines in the Chicago district and the effect of various methods of reducing these troubles have been kept. For Chicago conditions it appears possible to reduce the total number of transformer troubles annually caused by lightning to less than one per thousand transformers installed, through the adoption of the suggestions below:

1. Use the four-wire three-phase system of distribution with grounded neutral.

2. Install lightning arresters at locations where transformers are connected to overhead primary mains, using low voltage arresters on the neutral wire and valve type arresters suitable for the "Y" voltage on the phase wires.

3. Use transformers having insulation on the coils and leads that will not deteriorate with age and which will withstand a transient voltage test safely above the voltages to which the transformer will be subjected in service when protected by the arresters.

4. If conditions warrant, install a second ground wire and connect it to a second ground rod.

5. Select newest transformers for installation in districts of low transformer density.

6. Require each customer to ground his neutral wire to a water pipe on his premises.

7. Connect the neutral wire of each section of secondary main to at least two ground rods; and on long mains install ground rod connections at intervals not exceeding 600 ft.

8. Where transformers are connected to primary mains 1,500 ft. or more distant from the next adjacent transformers, install on the pole about 600 ft. from the transformers the same lightning arrester equipment as on the transformer pole.

9. Install lightning arresters on all cable poles.

10. Ground the lead sheaths of all underground primary cables. (A.I.E.E. Paper No. 32-19)

## Investigation of Lightning Protection for Distribution Transformers

By
T. H. Haines[12]
C. A. Corney[12]

A HISTORY is presented in this paper showing the results of lightning arrester protection for distribution transformers in New England, where the normal ground electrode resistance is much higher than in most other parts of this country. The general conclusions indicated by this study may be summarized as follows:

1. Experience has indicated that the application of lightning arresters to line transformers in areas affected by lightning reduces the trouble rate by about 50 per cent.

2. Variation in ground resistance within the values readily obtainable in this territory has slight effect upon the efficiency of the arrester.

3. The value of treating grounds or the installation of multiple grounds in an effort to lower resistance is questionable unless by so doing the resistance can be decreased to a value of approximately 100 ohms or less.

4. Insufficient electrical clearances in the smaller and older transformers are an important source of lightning trouble. Larger bushings, and greater clearances are clearly indicated as a necessary feature of correct transformer design. (A.I.E.E. Paper No. 32-44)

## Distribution System Lightning Studies by Philadelphia Electric Co.

By
H. A. Dambly[13]
H. N. Ekvall[13]
H. S. Phelps[13]

INVESTIGATIONS of lightning troubles have been conducted since 1921 on the distribution system of the Philadelphia Electric Company, to determine the magnitude and nature of trouble in various localities, the effectiveness of lightning arresters under field conditions, and methods for improving service continuity. The conclusions may be summarized as follows:

1. About 5 per cent of the aerial distribution transformers annually experience trouble due to lightning, the small transformers being the more susceptible.

2. Lightning arresters were found to afford little benefit to transformers of 15 kva. and less, and substantial benefit to the larger sizes.

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[10] Public Service Elec. & Gas Co., Newark, N. J.
[11] Commonwealth Edison Company, Chicago, Ill.
[12] The Edison Elec. Illum. Co. of Boston, Mass.
[13] Philadelphia Elec. Co., Philadelphia, Pa.

3. The obtaining of reasonable conclusions required that all major factors influencing lightning trouble be considered and all data be reduced to a common basis.

4. Because of the many factors involved, it has not been possible to determine thus far whether there is a material difference between the susceptibility to lightning trouble of grounded and ungrounded systems.

5. Low ground resistance may be obtained at low cost by connecting the arrester ground wire to the secondary circuit grounded neutral.

6. Customer interruptions from trouble on the primary system far exceed those from trouble on the secondary system.

7. The number of customer interruptions of less than 5 min. greatly exceeds the number of those of more than 5 min.; however, based on customer-hour interruptions, the order is reversed.

8. The major number of customer-hour interruptions due to all causes occur during electrical storms. At least one-half of these are attributable directly to lightning disturbances.

9. Lightning protection of distribution systems has been found to be of major importance from the standpoint of improving service continuity. (A.I.E.E. Paper No. 32-20)

## Equivalent Circuits

By
F. M. Starr[6]

EQUIVALENT circuits have been used from time to time in the solution of various magnetic and electrical problems. They have been found valuable in that they clarify the problem, simplify the analysis, and provide a means of replacing magnetic coupling with pure impedance links, thereby permitting the use of the calculating board for solution.

A particular problem has prompted a new study of representing a system of coupled circuits by an equivalent composed of pure impedance links. This problem arose primarily through the difficulty of representing adequately on the calculating board, groups of parallel transmission lines in which zero phase currents were flowing. In order to represent such a group on the calculating board it is necessary to replace the group with an equivalent circuit in which mutual impedance between the lines is simulated by pure impedance links. Closely related to the problem of coupled circuits is the general network problem.

In the present study the general equivalent mesh for the $n$-winding transformer is derived, as well as that for the mesh equivalent of the general network having $m + 1$ points of entry. These provide a background for the study of system networks involving groups of parallel transmission lines in such a manner as to simplify the problem greatly. These methods are perfectly general and may be applied to many other problems. (A.I.E.E. Paper No. 32-21)

## Transient Oscillations of Mutually Coupled Windings

By
L. V. Bewley[8]

IN THE PAST, the mathematical analysis of transient oscillations in transformer windings has been based upon a single winding having self and mutual inductances between its turns, capacitances along the stack and to ground, and, in one instance, resistances representing the losses. Such a circuit ignores the presence of secondary circuits, but strangely enough proves adequate to describe the internal high frequency transients of the winding under consideration, not only qualitatively but quantitatively as well. Cathode ray oscillograms, however, do show some difference in the characteristics of the oscillations, depending upon the terminal connections of the secondary circuit. Also, there is nothing in the single winding theory of transformer oscillations relative to the internal oscillations of the secondary circuit.

A mathematical study has been made of the oscillations occurring in the mutually coupled primary and secondary windings of a transformer when one of the terminals is subjected to the impact of a traveling wave. Solutions for grounded and open terminal conditions are obtained, but the general solution for any impedances at the terminals is not attempted, except for the initial distribution. (A.I.E.E. Paper No. 32-4)

## Geometrical Circuits of Electrical Networks

By
R. M. Foster[14]

IF ALL THE ELECTRICAL properties of a given electrical network are abstracted, there remains a geometric circuit completely characterized by the sets of branches terminating at the various vertexes. The use of such geometric circuits in place of the networks is desirable in the solution of a number of different problems. A successful application of this method requires to start with a complete enumeration of all distinct circuits classified according to certain specified properties.

In the present study enumerations of geometric circuits have been made, classified according to two different parameters, the nullity (number of branches minus number of vertexes plus number of separate parts) and the rank (number of vertexes minus number of separate parts). The geometric circuits which are symmetrical with respect to all branches and all vertexes, also have been listed. (A.I.E.E. Paper No. 32-22)

## The Breakdown of Glass With Alternating Potentials

By
N. D. Kenney[15]
A. M. Luery[16]
J. D. Moriaty[17]

THE FAILURE of solid dielectrics does not take place by one mechanism of breakdown but by several, different laws governing each type of failure. For some time thermal breakdown has been established as one of the mechanisms of puncture, and in 1928 there was found a type of breakdown in which the potential gradient is independent of temperature and thickness. This latter was spoken of as in the disruptive region. In 1929 a third type of breakdown was found lying between the previous two, and was termed as in the intermediate region.

These former experiments were conducted with direct potentials and additional experiments have been made recently to determine the results with alternating potentials. Glass was used as the test material.

It was demonstrated that three distinct regions of breakdown are obtained with alternating current, similar to those with direct current. In the disruptive and intermediate regions, it was found that breakdown occurs at an alternating peak voltage approximately equal to the direct breakdown voltage, while in the thermal region breakdown occurs at an alternating peak voltage somewhat lower than the direct breakdown voltage. (A.I.E.E. Paper No. 32-23)

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[14] American Tel. & Tel. Co., New York, N. Y.

[15] Mass. Institute of Technology, Cambridge, Mass.

[16] N. J. Bell Telephone Co., Newark, N. J.

[17] Bell Telephone Laboratories, Inc., New York, N. Y.

## The Predetermination of the A-C. Behavior of Dielectrics

By
J. B. Whitehead[5]
A. Banos, Jr.[5]

CHARGE and discharge currents of any type of dielectric under continuous potential make it possible to predict accurately the loss, power factor, and capacity at 60 cycles. This is done by an empirical determination of the equation for the relaxation function of the dielectric at a given temperature, followed by the application of von Schweidler's method. The method developed is available at any frequency, provided the continuous potential charge and discharge currents may be measured over initial time intervals comparable with the alternating period.

A convenient and sufficient expression for the relaxation function is shown in this paper to be a sum of three exponentials. Further, experiment and analysis prove that the method of three exponentials predicts accurately the a-c. behavior of a dielectric at 60 cycles. The usual forms of irreversible conduction encountered also are defined and classified. The case in which the initial constant current does not obey Ohm's law has been considered analytically as regards its contribution to the a-c. behavior. (A.I.E.E. Paper No. 32-45)

## Radio Interference from Insulator Corona

By
F. O. McMillan[18]

PUBLISHED in full in this issue of Electrical Engineering, p. 3-9. **Pamphlet copies not available.**

## Relationships Among the Magnetic Properties of Magnet Steels and Permanent Magnets

By
K. L. Scott[19]

OPEN CIRCUIT remanence of magnet steels is the magnetic induction at the magnetic equator of a permanent magnet with no external magnetizing or demagnetizing force. A new relationship has been found connecting the open circuit remanence of a permanent magnet with the factors determining its value. By plotting the ratio of remanence to residual induction as the ordinate, and using as the abscissa the ratio of the product magnet lengths times square root of coercive force to the product of equivalent diameter times the square root of residual induction, a curve is obtained which appears to be general and valid for all kinds of magnet steel.

Various quantities have been proposed for use as criteria of the magnetic quality of magnet steel, the quantity having the greatest theoretical justification being the maximum value of the product of the coordinates of the demagnetization curve for a given field, where the demagnetization curve is the portion of the hysteresis loop between residual induction and coercive force. Experimental justification of the validity of this criterion has been secured. However, it is approximated by the product of residual induction and coercive force, and as this latter quantity can be determined with less effort, it is preferable for routine use. (A.I.E.E. Paper No. 32-24)

## Auxiliary Drives for Steam Power Stations

By
F. H. Hollister[20]

ESSENTIALLY the full content of this paper is published in this issue of Electrical Engineering, p. 20-1. **Pamphlet copies not available.**

## Steam Driven Auxiliaries for Power Plants

By
W. P. Dryer[21]

ESSENTIALLY the full content of this paper is published in this issue of Electrical Engineering, p. 21-5. **Pamphlet copies not available.**

## Electrically Driven Auxiliaries for Steam Power Stations

By
L. W. Smith[20]

ESSENTIALLY the full content of this paper is published in this issue of Electrical Engineering, p. 25-8. **Pamphlet copies not available.**

## Proposed Definition of Terms Used in Power System Studies

By
H. K. Sels[10]

THE INSTITUTE'S subject committee on definitions has submitted its report on terminology for power system interconnection and stability studies. The report covers the five following general divisions: interconnection terms, stability terms, active power and reactive voltampere conventions, synchronous machine quantities, and response of excitation systems. In preparing its report the committee has reviewed technical literature and consulted representatives of members of various A.I.E.E. committees.

The definitions presented are descriptive and cover the field practically in its entirety. While many of these may be considered arbitrary, they have been chosen in the best interest of the profession. Their general adoption will lead to a better mutual understanding with less possibility of confusion and controversy on technical questions. (A.I.E.E. Paper No. 32M2)

## Experience with Electrical Stability of Conowingo Station of Philadelphia Electric Co. System

By
R. A. Hentz[13]
J. W. Jones[13]

A BRIEF description of the Philadelphia Electric Company system with particular reference to the features influencing stability of the Conowingo hydroelectric station is

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18. Oregon State College, Corvallis, Ore.
19. Western Electric Company, Inc., Chicago, Ill.
20. Sargent and Lundy, Inc., Chicago, Ill.
21. Stone and Webster, Inc., Boston, Mass.

given in this paper. It summarizes the various calculations and tests associated with the stability problem, and presents a record of operating experience from a stability standpoint during four years of service.

Several cases of instability due to line faults have occurred. A thorough study of the matter was undertaken and as a consequence changes were made in the equipment and system set-up, involving the development and installation of higher speed circuit breakers and relays.

Detailed records are given for all faults on those parts of the system intimately associated with the Conowingo development. These records show the improvement in stability obtained by the changes in the system and indicate attainment of a generally satisfactory condition. **(A.I.E.E. Paper No. 32-25)**

## Generalized Stability Solution for Metropolitan Type Systems

By
S. B. Griscom[2]
W. A. Lewis[2]
W. R. Ellis[2]

STABILITY studies of metropolitan type systems may be profitable not because instability has been a serious operating problem, but because such studies often may permit more reliable or economical layouts to be utilized safely. A simplified method for determining the degree of stability of any layout of a metropolitan type system is presented in this paper.

General stability curves are given by means of which the transient stability during faults may be determined. The results are obtained as the permissible fault duration in terms of certain indexes of the system and fault. For a particular fault these indexes may be found from a short-circuit study made on a d-c. calculating board or its equivalent; only three readings are required to obtain the result. **(A.I.E.E. Paper No. 32-26)**

## An Induction Motor with Paralleled Rotor and Stator

By
A. G. Conrad[24]
R. G. Warner[24]

A LITTLE known method of operating induction motors is to parallel the rotor and stator windings. When this is done the pull-out torque as a motor is approximately doubled and the continuous horsepower output may be increased; as an induction generator, the maximum kva. output is increased. The machine may be operated simultaneously as a motor and as a generator. For heavy loads the efficiency is higher than that of the same motor operated with its sliprings short-circuited; and if the motor is to operate over a wide range, maximum efficiency may be secured by using a switching arrangement to short-circuit the rings at light load.

By paralleling the rotor and stator windings the rating of a given motor may be increased, the initial cost of a motor required to drive a given load will be less, and the no-load losses may be made smaller. If the ratio of stator to rotor currents is other than approximately 1:1, the windings may be paralleled through an auto-transformer. This should improve performance, since the transformer will by-pass part of the low frequency current that ordinarily would flow through the supply transformers. Tests on a machine with rotor and stator paralleled directly, indicated two disadvantages: the machine was noisy and the exciting current was high. This, however, might be eliminated by special designing. **(A.I.E.E. Paper No. 32-27)**

## Some Considerations in the Design of Damper Windings For Synchronous Motors

By
C. C. Shutt[2]

EXTENSION of the application of synchronous motors to include more specialized fields requires that the design of damper windings for special starting performance become a more exact art. Possibilities and limitations in the performance which may be obtained by variation of the damper winding design are brought out by classification of the various types of these windings.

Damper windings may be classified arbitrarily as low reactance and high reactance types. The low reactance windings include those made up of round or rectangular bars of such size that skin effect has only a negligible influence upon the distribution of the current in the bar. These windings are well suited to give a high ratio of torque to kva., especially during the initial part of the starting period. Many other types of performance including fairly uniform torque over the starting period, or a low starting torque with high pull-out torque or a relatively low kva., can be obtained with high reactance windings. These include all forms of double-deck windings as well as bars which are subject to appreciable skin effect; also single-deck windings, the characteristics of which change noticeably as the motor comes up to speed. **(A.I.E.E. Paper No. 32-28)**

## Power Losses in Electrolytic Condensers

By
F. W. Godsey, Jr.[26]

ELECTROLYTIC condensers on a-c. circuits have higher power losses than would be expected from the leakage currents and electrolyte resistances. Likewise, losses change with the applied voltage, temperature of the cell, the frequency of the applied voltage, and with external circuit conditions governing current wave shape in such ways that it is almost impossible to predict results in advance. When a sine wave of voltage is impressed the current wave usually contains large harmonics, indicating a non-linear function in the impedance of electrolytic condensers. Increases in voltage, temperature, frequency, and concentration of the electrolyte also cause increases in the harmonics in the current wave.

A film on the anode surfaces saturated with the electrolyte solvent would explain the characteristics as measured and also make it possible to predict characteristics with some accuracy. Ion penetration of the outer regions of the film, and a comparatively continuous film near the anode, explain the non-linear characteristics. The variation of the electrolyte potential can be predicted on this basis, and power losses also are more easily predictable. **(A.I.E.E. Paper No. 32-30)**

## Film Characteristics of Electrolytic Condensers

By
F. W. Godsey, Jr.[26]

ELECTROLYTIC condensers of the film forming type have some interesting characteristics which have never been satisfactorily explained. Extremely thin oxide or hydroxide films, formed on the surface of the metal anodes, seem insufficient in themselves to explain the complete action. Likewise, an electromotive equilibrium is insufficient to explain the action.

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[24] Yale University, New Haven, Conn.

[26] Safety Car Heating & Lighting Co., New Haven, Conn.

Electrolytic condensers with extremely low applied voltages show large variations in measured capacity from high voltage measurements. The results indicate a film in which ion penetration plays a large part. Assuming the presence of a film saturated with water as the dielectric overcomes a number of former obstacles and lessens the necessity for the very thin films formerly assumed. (A.I.E.E. Paper No. 32-31)

## Electrical Precipitation

By
A. W. Simon[27]
L. C. Kron[27]

COTTRELL treaters have found many applications in various industries for the recovery or removal of smoke, dust, and fume particles from their containing gases. Precipitation efficiency, or percentage removal, depends upon a number of fundamental variables. A study made of these factors has placed the process on a more quantitative basis than formerly was possible.

Experiment shows in general that the precipitation efficiency increases with the treatment time, voltage, current, and power, according to a curve which partakes of the nature of that for a condenser charge; in other words, the relationships are exponential, and the cleaner a gas becomes the harder it is to remove more particles from it. The value of operating voltage above that necessary to produce corona was found to have little effect upon the cleaning efficiency, but the current flowing between electrodes and through the gases within the precipitator is of considerable importance to efficiency. (A.I.E.E. Paper No. 32-32)

## Commutation Considered As a Switching Problem

By
R. E. Hellmund[2]
L. R. Ludwig[2]

THE USUAL commutation theories deal with the reversal of the current in the commutating coil and with means for bringing about such reversal either along a straight line or curve. The principal object in such studies is to accomplish commutation without excessive current densities under the brush. Frequently, however, it is impossible to realize this, and the phenomenon which results is essentially one of switching. With this new concept in mind, factors may be studied which previously have not been considered.

For example, the mutual and self-inductance of the windings and their capacity may have an effect upon the energy to be dissipated during commutation. With this concept of switching in mind it can be seen that there may be a difference in commutation between shunt, series, or separately-excited machines, and with laminated or solid field structures, although the speed, current, and commutating fields are the same. Also, a-c. commutator machines may be affected by the transformer to which the machine is connected. Interesting results are obtained with two series-connected motors on a motor car, especially in a-c. motors having no damping effects in their field structure. During certain conditions each motor may have an effect upon the commutation of the other; this is explained readily by the switching theory. In general, the commutating phenomena cannot be considered as analyzed completely unless the possibilities of the switching phenomena as influenced by the various connected circuits have been given due consideration. (A.I.E.E. Paper No. 32-33)

## Equalizing Currents in the Armature of a D-C. Machine

By
R. M. Baker[2]

WHEN THE PARALLEL type winding was first used on the armatures of large d-c. machines, it was almost impossible to obtain sufficiently good magnetic balance of the main field circuits to permit satisfactory operation. In 1896 the idea was conceived of automatically balancing the flux in the main poles by connecting together those points on the armature which normally should be of the same potential. These equalizing connections have proved themselves capable of taking care of considerable unbalance in the same field; in fact their performance has been so satisfactory that little study has been given to the details of this action.

An increased knowledge of the behavior of these currents, however, has been secured by an analysis which is unique in that it is based upon experimentally determined curves of variation in equalizing current in an actual machine. The analysis shows definitely how these currents act to correct the unbalance causing their flow. It was found that even with very small inequalities of the main pole gaps the equalizing current in an armature coil may reach a peak value as high as 25 per cent of the full load coil current, several times each revolution of the armature. It has been shown also that the oscillograph is very useful in studying the behavior of equalizing connections, and that empirical results are obtainable without much difficulty. The securing of similar relations by an analytical method would be very complex. (A.I.E.E. Paper No. 32-5)

## Calculation of No-Load Damper-Winding Loss in Synchronous Machines

By
E. I. Pollard[2]

THE NON-UNIFORM nature of the air-gap due to the presence of alternate teeth and slots on the stator of synchronous machines results in a non-uniform distribution of flux density at the surface of the rotor. These pulsations in the air-gap induction produce pole-face loss. When a damper winding is present the pulsations link the damper bars producing circulating currents causing an additional loss which is designated by the term "no-load damper winding loss." The magnitude of this loss is found to vary from practically zero to as much as eight times the pole-face loss, or to as much as half of the total no-load core loss. A method now has been developed for calculating the no-load damper loss, based on theoretical considerations.

This study has indicated several ways by which the damper loss may be minimized. Changes in design to reduce pole-face loss also generally decrease the magnitude of damper loss, but the requirements in fundamental proportions of the machine usually require that these changes should not be made. The reduction of loss may be secured by keeping the number of bars on the machine and the bar resistance low. Perhaps the most powerful method of reducing loss is by adjustment of the ratio of rotor slot pitch to stator slot pitch. (A.I.E.E. Paper No. 32-34)

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[27] Tennessee Coal, Iron & Railroad Co., Birmingham, Ala.

# Sine Wave Generators

By
L. P. Shildneck[6]

CERTAIN applications, particularly testing, require a sine wave of generator voltage under all load conditions, and the round-rotor type of sine wave generator consequently was developed. The stator is similar to that of a salient-pole machine but for the field a round punched rotor is used with a double layer winding distributed in evenly spaced slots.

A comparison of various types of these windings shows that three newly developed connections called the *X*, *U* and *W* types are superior to the old *V* and *Y* types, in that 15 per cent or more increase in output can be secured from the rotor without increasing the maximum coil temperature rise or impairing the voltage wave shape. This change is wrought by eliminating the undesirable features of the old types; namely, too few active coils in the *V* type, and unequal leg heating in the *Y* type.

The analysis made in this connection is quite general and directly applicable to all round-rotor synchronous machines with double layer rotor coil windings as exemplified by sine wave generators and also synchronous induction motors. By selection of the proper connections any one of the factors desired, wave form, efficiency, and heating, can be stressed to any desired degree. (A.I.E.E. Paper No. 32-35)

# Engineering Features of Three-Power Locomotives

By
F. H. Brehob[28]
F. H. Craton[28]

AN ARTICLE based upon this paper is contained in this issue of ELECTRICAL ENGINEERING, p. 9-13. **Pamphlet copies not available.**

# Motors for 3,000-Volt D-C. Multiple Unit Cars

By
J. C. Aydelott[28]

A NEW MULTIPLE unit car motor incorporating many novel features of design was developed for the electrification of the suburban service of the Delaware, Lackawanna & Western Railroad, the first installation of multiple unit suburban service in this country employing a trolley potential of 3,000-volts direct current. The absence of trouble in commencing and maintaining service marks the whole electrification program.

There now are 564 of these motors in service on the Lackawanna railroad, and between August 1930 and June 1, 1931, 4,500,000 car miles have been operated with only two train delays chargeable to motor failure. During the period of initial operation the motors have been remarkably free from flashovers, insulation failures, and mechanical troubles. This preliminary operation indicated also that the maintenance expense will be unusually low. The securing of the many desirable features in motor design, and the consequent successful operation, may be attributed largely to the development of new design features. (A.I.E.E. Paper No. 32-36)

# Temperature Rise of Ventilated Railway Motor Armatures

By
D. A. Lightband[2]

THE CALCULATION of temperature rise and of time-temperature curves of a railway motor for which only preliminary design data are available, usually presents considerable difficulty. Modern railway practise demands increasingly large power units in a limited space, so that accurate methods are necessary for the predetermination of temperature rise. This must be used as a basis for guaranteed ratings and time-temperature curves in the application of a motor to a complicated service cycle.

Equations derived from the usual theory of heat flow between related bodies give a method for calculating the temperature rise of the armature in a new design of motor, for any time interval and load condition. Consistent results are given when applied to motors of widely varying size. By making certain assumptions the armature can be reduced to a simple equivalent model consisting of two conducting bodies separated by an insulating wall, and equations resulting from an analysis of this thermal system form a practical method of calculating time-temperature curves of an armature from preliminary design data. **(A.I.E.E. Paper No. 32-7)**

# Preparing Substations for Electric Operation

By
L. B. Curtis[29]

APPROXIMATELY forty substations are involved in the extensive electrification program recently announced for the Pennsylvania Railroad between New York and Washington; eleven of these already are in operation. A definite program for testing these substations before they are placed in operation has been evolved, and this procedure has been combined into a single set of test instructions.

The tests are separated into three groups: (1) preliminary tests without d-c. control or a-c. power; (2) tests with d-c. control but without a-c. power; and (3) tests with d-c. control and a-c. power. These test instructions are unusually complete and cover all possible sources of error which might interfere with the successful operation of the substation when it is placed in service. (A.I.E.E. Paper No. 32-37)

# The Time Services of the U.S. Naval Observatory

By
J. F. Hellweg[31]

ONE HUNDRED and one years ago the Naval Observatory was created. Since then it has had the determination and broadcasting of the nation's time. This is broadcast in mean solar time although kept in sidereal time. Measurement of time is based upon the earth's rotation and is very accurately observed and calculated. Observations are made by transit instruments with which the successive transits of predetermined stars are observed.

Because of its increasing importance in the nation's daily life great accuracy is demanded of the time service, and means of increasing this accuracy constantly are being sought. A new clock vault now is nearing completion. It will contain precision timepieces maintained at constant temperature and pressure at all times. The new clocks now are under construction and it is hoped that with this equipment, and modifications which are being planned, it will be possible to extend the time service, increase its accuracy, and add to the number of broadcasts per day. (**A.I.E.E. Paper No. 32-38**)

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[28] General Electric Co., Erie, Pa.

[29] Pennsylvania Railroad, Philadelphia, Pa.

[31] U.S. Naval Observatory, Washington, D. C.

## Time Services of the Telegraph Companies

By
G. W. Janson[32]

THREE CLASSES of time service are distributed by the telegraph companies. The first of these, commonly known as "noon beats" comprises the transmission during a three-minute period ending at noon eastern standard time of a series of electrical impulses originating from the naval observatory at Washington, D. C. This service is used very largely for correcting local master clocks throughout the United States once each day. The second time service commonly known as "jewelers' beats" comprises a similar transmission throughout the day of a series of coded impulses distributed in each locality by a master clock. These beats are used principally by jewelers for regulating timepieces.

The most extensive distribution of correct time by the telegraph companies is the automatic correction of clocks. The Western Union Telegraph Company's synchronizing system corrects about 120,000 clocks of which 95 per cent are rented to subscribers. These clocks operate independently but are reset to the correct time each hour by the telegraph synchronizing service. (**A.I.E.E. Paper No. 32-39**)

## Synchronous Electric Time Service

By
H. E. Warren[33]

PREVIOUS to 1916 no commercial a-c. system was regulated with sufficient accuracy of speed to enable its use for indicating time. Two devices then were developed making commercial a-c. time service possible. The first of these was a self-starting synchronous motor which utilized residual magnetism to enable the rotor to start and run at synchronous speed. The second consisted of an indicating instrument which would show to a generating station operator, directly in terms of time, deviations of average frequency from standard.

About 1928 several new varieties of synchronous motors suitable for use in clocks were developed. These may be divided into two classes, and self-starting and non-self-starting. The latter generally has toothed soft steel rotors, while the self-starting motors utilize a-c. fields with rotating components brought about by the use of shading coils. Both types now have been developed to require small power input and to eliminate hum. These are now being applied to many timing devices other than clocks.

The standardization of average frequency is of great value to the power companies in many ways other than the furnishing of time services. Further increase in the accuracy of control is to be expected from the use of automatic frequency control equipment which now is being developed. (**A.I.E.E. Paper No. 32-40**)

## New Key West-Havana Carrier Telephone Cable

By
H. A. Affel[14]
W. S. Gorton[18]
R. W. Chesnut[18]

A NEW SUBMARINE cable was laid recently between Key West and Havana to furnish increased telephone facilities between the United States and Cuba. This is the longest deep sea telephone cable in existence and also is unique in being the longest telephone cable circuit without intermediate repeaters and without inductive loading. The new cable operates at frequencies up to about 28,000 cycles per second; it has a single central conductor with concentric tape return, and employs the newly developed material paragutta for insulation. Due to the smaller dielectric constant and to the smaller leakance, the cable is much smaller in size than any of the three other cables between these countries.

A carrier telephone system provides three telephone channels and as ultimately developed, a still greater number of facilities may be made available. A large number of noise sources was investigated and the necessary methods for eliminating these were installed.

## The Development of a Handset for Telephone Stations

By
W. C. Jones[18]
A. H. Inglis[14]

A NUMBER of factors contribute to the difficulties involved in the design of a telephone handset which gives as good service performance as a deskstand. The handset transmitter for example not only is used in a wider range of positions but also is moved much more frequently, so that wider variations are experienced in its characteristics. The more severe use to which the handset is subjected requires special design measures to prevent an appreciable shortening of useful life.

Further difficulties are introduced by the close physical connection of the receiver and transmitter, in that "howling" tends to be set up. Also, the distance between the receiver and transmitter must be such as to be convenient for the user without introducing unnecessary losses in voice transmission in air.

The handset has been developed so that it overcomes all these difficulties and is interchangeable with the deskstand in existing telephone plant without important reaction on either transmission or signaling performance. That the design meets the wishes of the public is evidenced by the steady increase in demand to more than 1,000,000 sets per year at the present time.

## An Automatic Concentration Unit for Printing Telegraph Circuits

By
G. S. Vernam[34]

WHEN a number of lightly loaded telegraph circuits terminates at a central telegraph office, and the number of messages over each circuit is insufficient to keep the operator fully employed, these circuits usually are grouped together on a switchboard or "concentrator," so that a single operator can send and receive messages over any line of the group.

Printers or "teletypewriters" of the so-called "start-stop" type are being used to a large and increasing extent on such lightly loaded circuits, both by the telegraph companies and by private customers. As a result, concentration units are being used to an increasing extent for printing telegraph circuits.

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[32] Western Union Telegraph Co., New York, N. Y.

[33] Warren Telechron Company, Ashland, Mass.

[34] International Communications Laboratories, New York, N. Y.

Manually operated telegraph concentrators have been in use for many years, but an automatic concentrator now is being employed to permit the individual printer operators to set up their own connections. Outward calls are established by dialing without requiring multiple turrets or switching operators, and inward calls to idle positions can be established automatically without the delay involved in manual switching operations. Step-by-step automatic switches and calling dials are used, a number of special features being included.

## Carrier Application to a Telegraph Plant

By
R. E. Smith[34]
L. A. Kelley[34]

THE REQUIREMENTS for carrier systems in telegraph plants differ somewhat from those in telephone plants. Primarily these differences are due to the fact that telegraph plants are based upon the wide use of d-c. telegraph circuits which can be operated fairly successfully on a ground return basis. Furthermore, the operating energy levels of the various circuits on the same lead are not restricted by the presence of other types of communication circuits occupying a frequency transmission range other than that required for d-c. telegraph signals. Other equally important factors enter into the problem, and are outlined in this paper.

A description also is given of the transmission and equipment features of the system recently developed to meet the specific needs of the Postal Telegraph-Cable Company. The system is now in commercial service in the extensive open-wire plant of this company. Performance characteristics showing the capabilities of the system also are included.

## Forces of Electric Origin in the Iron Arc

By
F. Creedy[35]
R. O. Lerch[35]
P. W. Seal[35]
E. P. Sordon[35]

A NUMBER of phenomena are present in overhead arc welding, for which no adequate explanation has been possible. Among the questions are: (1) what is the force that causes the molten drop to travel across the arc face from the electrode to the work, (2) why is it that the drop is detached with explosive violence rather than gradually? In an attempt to determine the electric origin of these forces in high current metallic arcs, the magnified image of an arc was projected on a screen by means of a lens. In this manner, relations between the electrical forces, arc currents, and arc lengths were studied.

General conclusions may be drawn from these results indicating that the force which detaches the globule from the welding rod may depend upon the "pinch effect" due to the magnetic field tending to force the outer portions of a conductor toward the center. As the cross-section of the area between the globule and the electrode becomes smaller, the pressure is increased as the square of the current density. The force tends to sever the part still attached. This appears to be the cause of the explosive violence with which the globule is detached. It appears that as soon as the globule is separated it is carried over by the force of the reaction resulting from the emission of minute particles at high temperature. **(A.I.E.E. Paper No. 32-41)**

## An Improved A-C. Arc Welder

By
A. M. Candy[2]

THE COST OF APPARATUS for arc welding with the a-c. arc is less than that for the d-c. arc. In spite of this the d-c. arc has been used much more extensively because: the open circuit voltage of the a-c. welder was about double that of the d-c. equipment with a consequent increased life hazard; the a-c. arc was much more difficult to strike and hold; and it also drew a low power factor current from the line.

By imposing a high frequency on the welding circuit all these disadvantages of the a-c. arc welder have been overcome. The voltage developed by the oscillator circuit is sufficiently high to start the discharge in the arc just before the electrode contacts the work; for this reason the arc starts easily, sticking of the electrode to the work is eliminated, and a lower voltage may be used for the basic frequency arc. The necessity for a high leakage reactance to throw the voltage and current out of phase so as to maintain the current when passing through zero is eliminated. Consequently the power factor is considerably improved; in fact it is approximately 90 per cent, which is even better than that of an induction motor driving a d-c. generator for d-c. welding.

The quality of the weld made with this improved a-c. welder is equal in every respect to that of d-c. welds. Because of the low no-load losses, the low investment charges, and low maintenance costs resulting from the absence of any rotating parts, the a-c. welding equipment is very economical to operate especially when welding materials of 16 gage or less. **(A.I.E.E. Paper No. 32-42)**

## Recent Developments in Design of Arc Welding Generators

By
K. L. Hansen[36]

A DROOPING volt-ampere characteristic is required of an arc welding generator in order to overcome the instability of the arc due to its negative resistance characteristic. Where there are abrupt changes in the arc resistance, as in metallic arc welding, this requirement becomes complex and exacting. Other desirable design features are as follows:

1. Elimination of the external reactor sometimes used to smooth out current fluctuations.
2. Reflection of current impulses in the main circuit back into the field to quicken field flux changes and thereby make the machine more responsive to changes in the external resistance.
3. Elimination of the exciter without resorting to the two-pole armature four-pole field structure.
4. Elimination of all regulating rheostats and switches without interfering with the desirable characteristics of the generator.

In a new completely self-contained arc welding generator, the first two of the objects enumerated above have been obtained by a novel design of the commutating winding, shunt windings, and main poles, and by adding a special winding consisting of one turn short-circuited upon itself. Suitable excitation is secured by two sets of auxiliary brushes spaced from 50 to 60 electrical degrees ahead of the main brushes. Adjustment of the brushes enables the current to be varied. The resultant machine is very fast in response to variations in external resistance, and retains over a wide range of operation the characteristics desired in an arc welding generator. **(A.I.E.E. Paper No. 32-43)**

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[35] Lehigh University, Bethlehem, Pa.

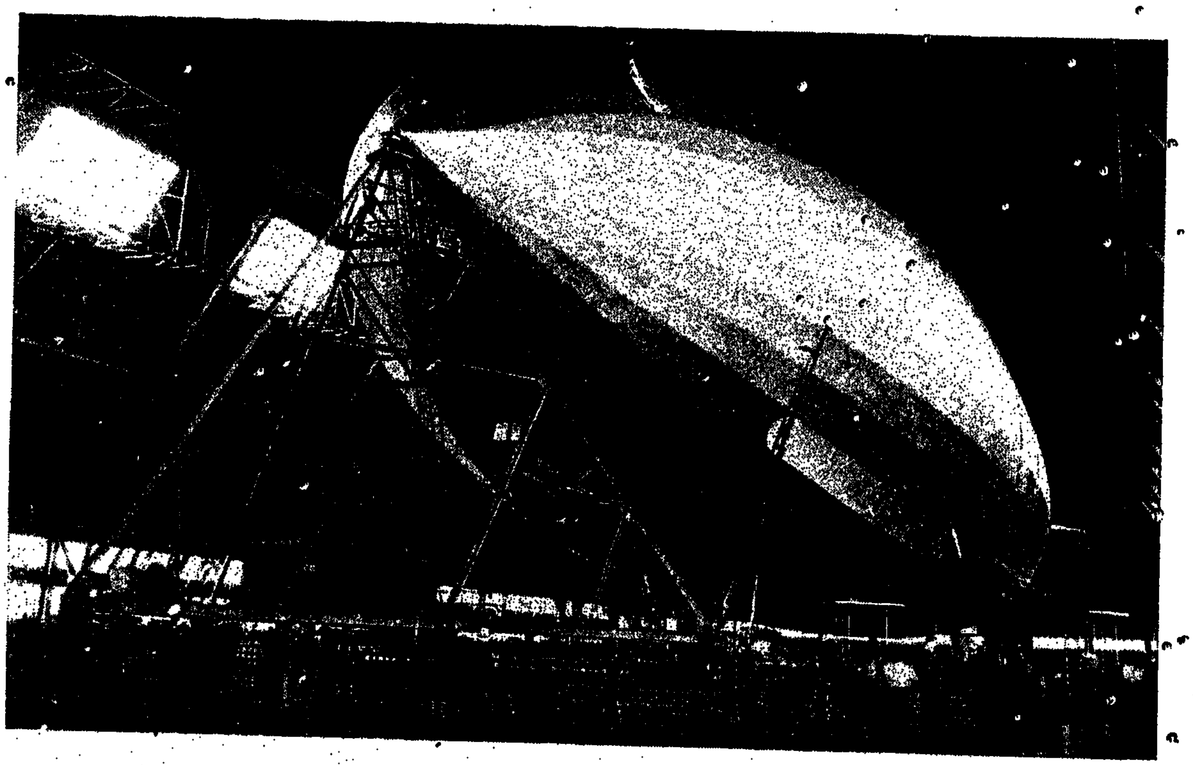
[36] K. L. Hansen Engg. Co. Inc., Milwaukee, Wis.

# News
## Of Institute and Related Activities.

# Winter Convention Arrangements Completed

## Fourteen Technical Sessions and Other Features Offered

EVERYTHING is in readiness for the 1932 A.I.E.E. winter convention which will be held with headquarters in the Engineering Societies Building, 33 West 39th Street, New York, N. Y., January 25-29. An excellent schedule of events embracing fourteen technical sessions, a variety of inspection trips and social functions, and a special program for women guests has been completed.



The U.S.S. Akron "riding at anchor" in the Lakehurst, N. J. "dock"

### Technical Sessions

Three of the technical sessions comprise important symposiums: (1) distribution circuit lightning protection, (2) system stability, (3) time and time services. Lightning as it is related to transmission lines has been treated often, but relatively little has been brought forth on the subject of distribution circuit lightning protection. Consequently this session should fill a gap in this field. System stability and its intricate relations when systems are interconnected offer a timely topic of interest to many groups. Valuable data and experience gained in this particular field will be brought out through the cooperation of manufacturing and operating companies. Likewise the symposium on time and time services will present valuable and interesting information on this modern phase of the art. With eleven other specialized sessions the program leaves little to be desired from a standpoint of technical interest.

Detailed information concerning this convention was published on p. 971-2 of Electrical Engineering for December, 1931. Additional information and a few minor changes are outlined in the following paragraphs.

The session on research which formerly was scheduled for Tuesday afternoon will be held on Wednesday morning in parallel with the symposium on stability. The first paper formerly listed in the session on research "Some Fundamental Theory and Experiments on Electrical Precipitation" by A. W. Simon and L. C. Kron, will be presented Thursday morning in the electrochemistry-metallurgy session.

The selected subjects session will be entirely devoted to a symposium on steam power station auxiliary drives.

A paper "Preparing Substations for Electric Operation" by L. B. Curtis, Pennsylvania Railroad, has been scheduled for presentation in the session on transportation.

### John Fritz and Edison Medals

Two of the most highly prized rewards for engineering accomplishments will be presented in the Engineering Auditorium on the evening of Wednesday, January 27.

The Edison Medal will be presented to Dr. Edwin Wilbur Rice, Jr., for his contributions to the development of electrical systems and apparatus and his encouragement of scientific research in industry.

The John Fritz Medal will be presented to Dr. Michael Idvorsky Pupin for his accomplishments as a leading scientist, engineer, and author, and as inventor of the tuning of oscillating circuits and the loading of telephone circuits by inductance coils.

Details of the award of the John Fritz Medal were published in Electrical Engineering, Nov. 1931, p. 911. Details of the award of the Edison Medal are published on p. 61 of this issue.

### Entertainment Features

A buffet supper (served by Louis Sherry) and smoker with entertainment will be held in the headquarters building on Tuesday evening, January 26. This informal occasion affords a splendid opportunity to renew old acquaintances and to make new ones. Tickets will be $3 per person.

The dinner dance, for many years an outstanding social event of the Institute, will be held in the Grand Ballroom of the Hotel Astor, Thursday evening, January 28. Tickets will be $6 per person. Reservations may be made in advance for tables seating eight or ten people.

For women guests a specially planned program has been arranged by the ladies' entertainment committee under the chairmanship of Mrs. E. B. Meyer.

On Wednesday, January 27, 6:30 p.m.,

graduates of Columbia University will dine at the Columbia University Club, 4 West 43rd Street, in an informal get-together dinner which will finish in time to enable them to attend the regular evening session. Price $1.50. For reservations address A. D. Hinckley, Columbia University.

### REGISTER IN ADVANCE

Each member should register in advance by mail, thus permitting the committee in charge to have the badges ready, saving time and reducing congestion at the registration desk. A card for this purpose was included in the mailed announcement.

Reservations for hotel accommodations should be made by writing directly to the hotel chosen. Rates for some of the hotels were listed in the mailed announcement.

### REVISED SCHEDULE OF EVENTS

Monday morning and evening have been left open for committee meetings. Capital letters A, B, etc., denote technical sessions.

**Monday, January 25**

10:00 a. m. Registration
2:00 p. m. Opening of Convention
A—Protective Devices
B—Instruments and Measurements

**Tuesday, January 26**

10:00 a. m. C—Symposium on Distribution Circuit Lightning Protection
D—General Circuit Theory
2:00 p. m. E—Selected Subjects
6:00 p. m. Buffet Supper and Smoker

**Wednesday, January 27**

10:00 a. m. F—Symposium on System Stability
G—Research
1:15 p. m. Inspection Trips
2:00 p. m. Board of Directors Meeting
8:30 p. m. Edison Medal and John Fritz Medal Presentations

**Thursday, January 28**

10:00 a. m. H—Electrical Machinery
I—Electrochemistry and Electrometallurgy
2:00 p. m. J—Electrical Machinery
K—Transportation
7:30 p. m. Dinner Dance

**Friday, January 29**

10:00 a. m. L—Symposium on Time and Time Services
2:00 p. m. M—Communication
N—Electric Welding

### INSPECTION TRIPS

Attention of all of those who will attend the convention is called to the fact that members of the inspections trips committee will be pleased to assist in the making of necessary arrangements for the visiting of neighboring plants or other points of special interest. The committee asks that members make known their desires as soon as possible after arrival.

**U.S. Naval Air Station and U.S.S. Akron**

The great Navy dirigible *U.S.S. Akron*, the building of which was started November 7, 1929, and completed August 8, 1931, when it was christened by Mrs. Herbert Hoover before approximately 150,000 people, now is stationed at the Naval Air Station at Lakehurst, N. J. The committee has arranged for an inspection of this world famous battleship of the air. Through the hospitality of the commanding officer of the air station, the hangars will be visited Wednesday afternoon, January 27, when both the *Akron* and the *Los Angeles* are scheduled to be there. Special arrangements are being made with the railroad, which will furnish accommodations at a very reasonable figure.

**Scenic Trip via George Washington and Bear Mountain Bridges**

During the last convention, an inspection trip was made to the George Washington Bridge, then under construction. This engineering monument with its 3,500 ft. suspension span, the longest in the world, is now completed and in service forming an important traffic artery between New York and New Jersey. Further up the Hudson River at Bear Mountain is another famous span which forms an important connecting link between the highways on either side of the Hudson River. A ride over the highways in this vicinity provides a magnificent motor trip. De luxe buses will, on Wednesday afternoon, January 27, start from the Engineering Societies Building, cross the new George Washington Bridge, travel north up the Hudson River on the top of the Palisades to the Bear Mountain Bridge, cross the Bear Mountain Bridge and return to the starting point via scenic New York State highways.

**New Jersey Industrial Area**

For those who would enjoy a bus trip through the industrial area of New Jersey, with brief stops at points of specific interest, a trip is in contemplation and will be described more fully in the convention literature.

**Other Points of Interest**

Opportunity will be afforded to those who wish to visit the installations of the neighboring utilities, railroad electrifications completed or in progress, or industrial and other enterprises which may command the interest of the members and their guests. Inspection privilege to visit the following places of interest has been accorded:

1. The Delaware, Lackawanna and Western Railroad Electrification
2. Roseland (N. J.) switching station of the Public Service Electric and Gas Company
3. 160,000-kw. tandem compound units of the Brooklyn Edison Company, and the company's research laboratory
4. East River generating station of New York Edison Company
5. New Eighth Avenue Subway substations
6. Vertical distribution in Empire State Building
7. Electrical Testing Laboratories
8. Lighting institute of the New York Electrical Society
9. New three-power locomotives of New York Central Railroad used for switching on West Side lines in New York City
10. Studio of Jenkins Television Corporation, where actual television broadcasting of dramatic sketches, and their reproduction as received on local receiver, may be witnessed
11. Lawrenceville (A.T.&T.) short wave radio station, and also control room at 24 Walker St., for ship-to-shore and transatlantic Service
12. Time service bureaus of New York Telephone Company, and Western Union Telegraph Company
13. Teletypewriter exchange service of American Telephone and Telegraph Company at 24 Walker St.
14. New York Museum of Science and Industry, where may be seen the new permanent exhibits relating to power, and electrical science and technology
15. New Lighting of the Statue of Liberty (See front cover)
16. Network protector exhibit and time control of street lighting circuits

200,000-kva. turbine-generator unit recently installed in the Brooklyn Edison Company's Hudson Avenue Station

## Institute Directors Hold December Meeting

The regular meeting of the A.I.E.E. board of directors was held at Institute headquarters, New York, December 4, 1931.

Present were: *President*—C. E. Skinner, East Pittsburgh, Pa. *Past-president*—W. S. Lee, Charlotte, N. C. *Vice-presidents*—H. P. Charlesworth, New York, N. Y.; L. B. Chubbuck, Hamilton, Ont.; A. W. Copley, San Francisco, Calif.; W. B. Kouwenhoven, Baltimore, Md.; T. N. Lacy, Detroit, Mich.; I. E. Moultrop, Boston, Mass.; P. H. Patton, Omaha, Neb. *Directors*—L. W. Chubb, East Pittsburgh, Pa.; A. B. Cooper, Toronto, Ont.; B. D. Hull, Dallas, Tex.; J. Allen Johnson, Buffalo, N. Y.; A. E. Knowlton, New York, N. Y.; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New York, N. Y.; R. H. Tapscott, New

York, N. Y.; H. R. Woodrow, Brooklyn, N. Y. *National Treasurer*—W. I. Slichter. *National Secretary*—F. L. Hutchinson, New York, N. Y.

The minutes of the directors' meeting of October 23, 1931, were approved.

The following minute was adopted in memory of the late Dr. L. T. Robinson:

> In the keen appreciation of the loss sustained by the field of electrical engineering and by the American Institute of Electrical Engineers through the death on November 3, 1931, of Dr. Lewis Taylor Robinson, the board of directors of the Institute adopts this minute and directs that a copy be sent to Dr. Robinson's family:
>
> "In the passing of Lewis Taylor Robinson, there was removed from the profession of electrical engineering one of the men to whom that profession is most deeply indebted; who, as an Institute worker, gave generously of his time through service as manager and vice-president, and member for many years of the standards and many other committees; a man whose unselfish interest and devotion served as a steadying and guiding influence, and whose sound judgment and pleasing personality won for him throughout his long years of service the high respect of the many with whom he came in contact."

A report of a meeting of the board of examiners held November 24, 1931, was presented and approved. Upon the recommendation of the board of examiners the following actions were taken upon pending applications: 789 Students were enrolled; 45 Associates were elected; 7 applicants were elected to the grade of Member, and 15 were transferred to the grade of Member.

Approval by the finance committee of monthly bills amounting to $24,129.97 was ratified.

A resolution was adopted to the effect that the 1932 annual (business) meeting of the Institute will be held on Monday, June 20, at Cleveland, Ohio.

Appointments were made as follows: H. H. Barnes, Jr., as a member of the Edison Medal committee, succeeding Dr. L. T. Robinson (deceased); H. S. Osborne, successor to Doctor Robinson, as a representative of the Institute on the standards council of the American Standards Association; A. W. Berresford as an Institute representative on the board of trustees of the United Engineering Trustees, Inc., for the three-year term beginning January 1, 1932; and W. S. Barstow reappointed to the library board of the United Engineering Trustees, Inc., for the four-year term beginning January 1, 1932.

A communication from W. S. Barstow was presented, in which he advised of his intention to present to the Institute, a bronze bust of Thomas A. Edison (a replica of the marble bust presented last April to the Deutsches Museum, Munich, Germany) and the following resolution was adopted:

> RESOLVED, That the board of directors of the American Institute of Electrical Engineers hereby expresses to Mr. William S. Barstow, a former director and vice-president of this Institute and now president of the Edison Pioneers, its high appreciation of his action in presenting to the Institute a bronze bust of Thomas A. Edison, and directs that this bust be placed upon exhibition in a prominent place at Institute headquarters.

The following new by-law was adopted, defining the scope of the committee mentioned therein:

> The committee on economic status of the engineer shall consist of five members, and shall consider matters relating to the position, function, and responsibility of the engineer in the development of human welfare, and make reports and recommendations thereon to the board of directors. The committee shall cooperate with similar committees of other engineering societies, and shall also consider and report upon all matters referred to it by the board of directors, the president, and the national secretary.

In response to an invitation to be represented at the Seventh American Scientific Congress to be held in Mexico City, February 5-19, 1932, President Skinner was appointed as the Institute's delegate to this congress.

Upon invitation from the Kelvin Medal board of award (of England) to nominate a candidate for the award of the Kelvin Medal in 1932, the president was authorized to appoint a committee to report recommendations at the January meeting of the A.I.E.E. board.

The board accepted offers from Past-Presidents Ralph D. Mershon and William S. Lee each to donate a golf trophy (to replace the Mershon Cup which in June 1931 passed into the permanent possession of L. F. Deming of Philadelphia, and authorized the appointment of a committee to work out the details in connection with both trophies.

Consideration was given to a request from the Institute of Electrical Engineers of Japan for assistance in carrying out two projects under the Iwadare Foundation, as follows: (1) Sending Japanese electrical engineers to the United States each year to study, and (2) inviting each year distinguished electrical engineers from the United States to deliver several lectures in Japan. The appointment of a continuing committee to carry on this activity was authorized.

Approval was given to a proposal by The Engineering Foundation to establish a research procedure committee, consisting of one representative from each of the four national societies of civil, mining and metallurgical, mechanical, and electrical engineers, and two representatives of The Engineering Foundation. The president was authorized to appoint the Institute's representative on this committee. (President Skinner later designated L. W. Chubb, chairman of the Institute's committee on research.)

A report was received from G. L. Weller, the Institute's representative at the Fourth Pan-American Commercial Conference, held in Washington, October 5-13, 1931.

Other matters were discussed, reference to which may be found in this and future issues of ELECTRICAL ENGINEERING.

# A.I.E.E. Nominating Committee Announces Official Candidates for 1932

A COMPLETE official ticket of candidates for the Institute offices that will become vacant August 1, 1932, was selected by the national nominating committee which met at Institute headquarters, New York, December 3, 1931. This committee consists of fifteen members, one selected by the executive committee of each of the ten geographical districts, and the remaining five elected by the board of directors from its own membership.

The following members of the committee were present: C. T. Almquist, Norman, Okla.; F. J. Chesterman, Pittsburgh, Pa.; A. B. Cooper, Toronto, Ont.; A. W. Copley, San Francisco, Calif.; Bancroft Gherardi, New York, N. Y.; B. D. Hull, Dallas, Tex.; W. B. Kouwenhoven, Baltimore, Md.; T. N. Lacy, Detroit, Mich.; P. H. Patton, Omaha, Neb.; C. E. Rogers, Seattle, Wash.; C. E. Stephens, New York, N. Y.; R. H. Tapscott, New York, N. Y. (alternate for A. M. MacCutcheon, of Cleveland, Ohio); R. G. Warner, New Haven, Conn.; and F. L. Hutchinson, New York, N. Y., secretary of the committee. Past-President Bancroft Gherardi was elected chairman of the committee.

The following is a list of the official candidates as selected by the committee:

### FOR PRESIDENT

H. P. Charlesworth, vice-president, Bell Telephone Laboratories, New York, N. Y.

### FOR VICE-PRESIDENTS

North Eastern District (No. 1): J. Allen Johnson, chief electrical engineer, Buffalo, Niagara & Eastern Power Corporation, Buffalo, N. Y.

New York City District (No. 3): E. B. Meyer, vice-president, United Engineers & Constructors Inc., Newark, N. J.

Great Lakes District (No. 5): K. A. Auty, sales engineer, Commonwealth Edison Company, Chicago, Ill.

South West District (No. 7): G. A. Mills, chief engineer, Central & South West Utilities Company; vice-president, Pecos Valley Power & Light Company, Dallas, Tex.

North West District (No. 9): C. R. Higson, superintendent of distribution, Utah Power & Light Company, Salt Lake City, Utah.

### For Directors

G. A. Kositzky, chief engineer, The Ohio Bell Telephone Company, Cleveland, Ohio.

A. H. Lovell, assistant dean and professor of electrical engineering, University of Michigan, Ann Arbor, Mich.

A. C. Stevens, in charge, educational sales, General Electric Company, Schenectady, N. Y.

### For National Treasurer

W. I. Slichter, professor of electrical engineering, Columbia University, New York, N. Y.

The constitution and by-laws of the Institute provide that the nominations made by the national nominating committee shall be published in the January issue of Electrical Engineering. Provision is made for independent nominations as indicated in the following excerpts from the constitution and by-laws:

### Constitution

Sec. 31. Independent nominations may be made by a petition of twenty-five (25) or more members sent to the National Secretary when and as provided in the By-laws; such petitions for the nomination of Vice-Presidents shall be signed only by members within the District concerned.

### By-Laws

Sec. 23. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with Article VI, Section 31 (Constitution), must be received by the secretary of the National Nominating Committee not later than February 15 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the National Nominating Committee in accordance with Article VI of the Constitution and sent by the National Secretary to all qualified voters during the first week in March of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

(*Signed*) National Nominating Committee
By F. L. Hutchinson,
Secretary

### Biographies of Nominees

That those not personally acquainted with the nominees may know something of them and their qualifications for the offices for which they have been recommended, brief biographical sketches of each are given herewith.

### H. P. Charlesworth

Harry Prescott Charlesworth was born in Haverhill, Mass., April 7, 1882. After graduation by the Massachusetts Institute of Technology in 1905 with the degree of Bachelor of Science, Mr. Charlesworth entered the engineering department of the American Telephone and Telegraph Company, then located in Boston. His early assignments had to do with the development of telephone circuits and associated apparatus. Later he was active for several years in the development of toll operating methods and the general related engineering problems involved in extending and improving telephone service.

With the opening of the war he was specially assigned to handle problems wherein the Bell System could be of assistance to the government in the national emergency. In this capacity he was, throughout the war, active on communication facilities for army camps, naval bases, supply depots and particularly for the government departments at Washington, where he also assisted the telephone company on general equipment and traffic engineering matters.

Shortly after the close of the war he became for a short time equipment and transmission engineer of the American Telephone and Telegraph Company; in 1920 was appointed plant engineer of that company, in which position he was concerned with all phases of the engineering of the telephone plant and with relations with other wire using companies. In December 1928 he was elected vice-president of Bell Telephone Laboratories, Inc., where he now directs operations involving more than 5,000 people engaged in development, research and related activities pertaining to the communication art.

Mr. Charlesworth became a Member of the Institute in 1922 and a Fellow in 1928. Also, he was a manager (1924-1927), chairman of the meetings and papers committee (1927-1929), and chairman of the New York Section (1929). In 1930 he became vice-president (representing District No. 3) and member of the board of directors. He has served on many Institute committees, being at present a member of the executive, coordination, Institute policies, finance, legislation affecting the engineering profession, technical program, and the Edison and Lamme Medal committees. He also is a representative of the Institute on the board of United Engineering Trustees, Inc.; a member of the National Research Council's division of engineering and industrial research, vice-chairman of the A.S.A. electrical standards committee, and a member of several other scientific organizations.

### J. Allen Johnson

Joseph Allen Johnson was born at Northboro, Mass., June 21, 1882, and received his early education in the schools of that town. He was graduated from the Worcester Polytechnic Institute with the degree of Bachelor of Science in electrical engineering in 1905.

From 1905 to 1912, he was employed in electrical engineering work by the Ontario Power Company of Niagara Falls, being appointed electrical engineer of that company in 1912. In 1917 this company was purchased by the Hydroelectric Power Commission of Ontario, of which Mr. Johnson became assistant engineer, but still retained his other position. In 1918 he was appointed electrical engineer of the Cliff Electrical Distributing Company and Hydraulic Power Company of Niagara Falls, N. Y. and with the consolidation of these companies and the old Niagara Falls Power Company to form The Niagara Falls Power Company in 1918, he became electrical engineer of the enlarged company. In 1929 he was appointed chief electrical engineer of the Buffalo Niagara & Eastern Power Corporation, which position he now holds.

Mr. Johnson has contributed several important technical papers on such subjects as excitation and voltage control, reactors in hydroelectric stations, fire protection in a-c. generators, retardation method of loss determination. In 1926 he was awarded the "best paper" prize for District No. 1, for his paper "The Retardation Method of Loss Determination as Applied to the Large Niagara Generators."

He joined the Institute as an Associate in 1907, and was transferred to the grade of Fellow in December 1927. He has served as a member of the electrochemistry and electrometallurgy, electrical machinery, and protective devices committees. He became a director of the Institute in 1928 and served as chairman of the membership committee for the two years 1929-31. He was the organizer and first chairman of the Niagara Frontier Section and served in that

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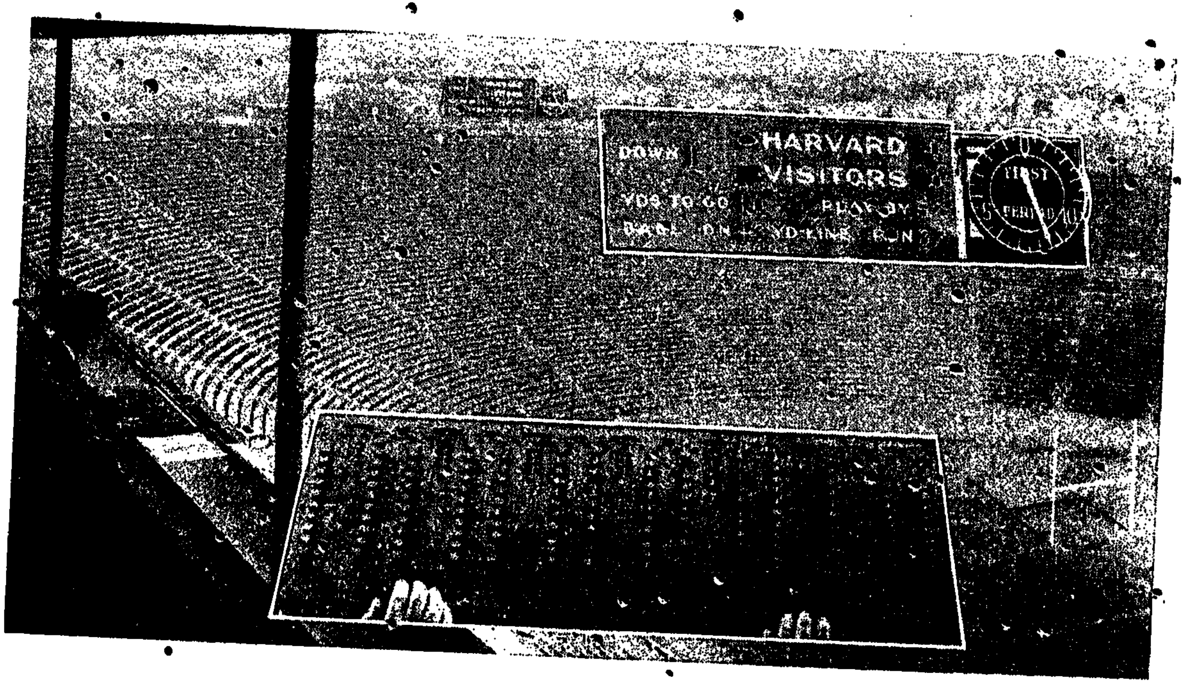
## A Scoreboard Visible Against Sunlight



This new electric scoreboard at Harvard's stadium, Cambridge, Mass., makes it possible for spectators to follow the ball, penalties, players, plays, and the score, with comparative ease. Moreover, the figures that flash across this new board are accurate and perfectly in time with the play itself, for the action of the board is controlled by a push-button station on the 50-yard line. The board, built by the General Electric Company, is 30 ft. long and 12 ft. high. The face is dull black and the ball and numeral indications are flashed to the spectators by groups of incandescent lamps so controlled that their brilliance varies with the amount of natural light over the field. Even with bright sunlight the numbers are clearly visible at 300 yd.

capacity from the date of its organization, February 10, 1925 to July 31, 1926.

He also is a member of the National Electric Light Association and the American Association for the Advancement of Science.

## E. B. Meyer

**Edward Barnard Meyer** was born October 22, 1882, at Newark, New Jersey. He received his technical education at the Newark Technical School, from which he was graduated in 1901, and at Pratt Institute, Brooklyn, New York, whence he graduated from the electrical engineering course in 1903.

That same year, Mr. Meyer entered the employ of Public Service Corporation of New Jersey as an engineering assistant and remained continuously with that organization and its subsidiary companies until 1922, holding successively the positions of field engineer (1906) in charge of the underground conduit and cable systems, assistant engineer (1909) supervising the preparation of special estimates and reports and of construction operations, and assistant chief engineer (1919). With the formation in 1922 of the Public Service Production Company he was appointed its chief engineer.

In 1929, Mr. Meyer was made a vice-president of Public Service Production Company, and in 1930, on the occasion of the merging of that company with United Engineers & Constructors Inc., he was appointed a vice-president of the latter corporation in the capacity of executive and engineering head of the Newark office.

Mr. Meyer became an Associate of the Institute in 1905, transferring in 1927 to the grade of Fellow. Active in Institute service, Mr. Meyer now is chairman of the following Institute committees: publication, award of Institute prizes, constitution and by-laws, Edison Medal, and the winter '32 convention; a member of the following committees: coordination of Institute activities, power generation, and representative for the Institute on the engineering societies monographs committee. Within recent years Mr. Meyer has been chairman of A.I.E.E. committees on meetings and papers (now technical program), transmission and distribution, finance, and executive committee of the New York Section; a member of the headquarters, Sections, membership, and several special and subcommittees. Also he was the Institute's representative on the U.S. national committee I.E.C.

Mr. Meyer's other technical activities have included active participation in N.E.L.A. and A.S.A. affairs, membership on the board of directors of the New York Electrical Society, Inc., membership in the Essex (County, N.J.) Electrical League, the U.S. Chamber of Commerce, the A.S.M.E., and the A.E.R.A. During the World War he served on important committees of the U.S. Army and Navy. His numerous contributions to the technical press have dealt chiefly with electric transmission and distribution problems and includes his book "Underground Transmission and Distribution."

## K. A. Auty

**Karl André Auty** was born in Yorkshire, England, of English parents and is now in his fifties. His education was pursued in Wheelwright Grammar School, *H.M.S. Conway* a British Naval Training Ship, and in the military class of a Paris university.

Family circumstances having changed, he took the engineering course at Victoria University, Nottingham. He then (1899) entered the Brush Electrical Engineering Company (England) as an engineering pupil for a three-year practical and theoretical engineering course.

Subsequently Mr. Auty came into charge of the Brush company's Lancashire district office, making a specialty of electrifying textile mills and old fashioned traction systems. In 1909 he became the illuminating and power engineer and headed the sales promotional department of the British Columbia Electric Railway Company in Vancouver, Canada. During the period of his affiliation with that company he was an active participant in the organization of the Vancouver Section of the Institute, and in the newly formed company Section of the N.E.L.A. Also he became a member of the Illuminating Engineering Society. Late in 1915 he joined the Commonwealth Edison Company of Chicago, Ill. as power sales engineer in the contract department. During the World War, he also assisted the State Council of Defense of Illinois. In 1917, he won the Insull medal for his paper "Advertising our K.W.H.'s."

Mr. Auty became an Associate of the Institute in 1912, and in 1917 was transferred to the grade of Member. He has been secretary, (1924-5), vice-chairman (1925-6), and chairman (1926-7) of the Chicago Section, and a member of the 1929 and 1930 national nominating committees. As an active member of the Western Society of Engineers (Chicago) he has served as chairman of its electrical section (1926-7), member of its board of management, and member of its Washington Award commission (1927-9). He is an Associate of the Association of Iron and Steel Electrical Engineers. He assisted in the original foundation of the Midwest Power Engineering Conference, and for the past four years has served as its treasurer. He is an earnest advocate and ardent promoter of amateur sports, and is serving as president of several amateur athletic organizations.

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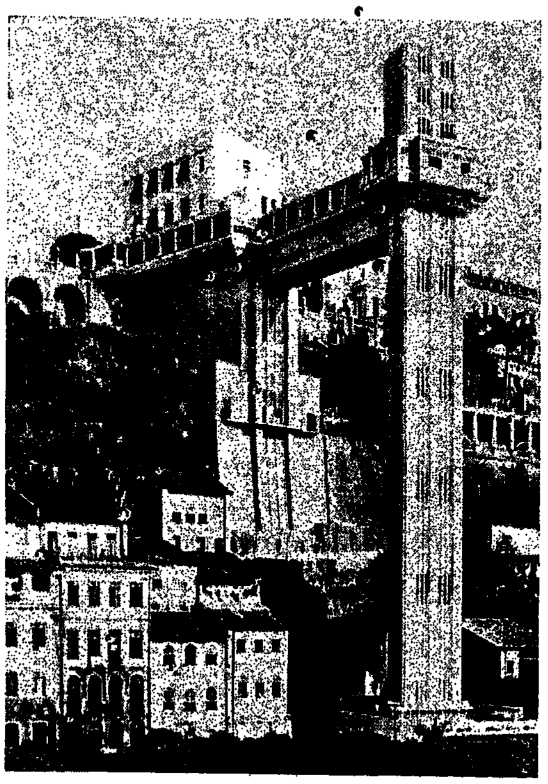
## Vertical Transportation



To CONNECT a bay front business district with a residential district 195 ft. above it, La Cerda Tower was placed in operation recently in Bahia, a coastal city in northern Brazil. The reinforced concrete tower is 240 ft. high and houses two large Otis express elevators reputed comparable with those used in the largest modern skyscrapers. On the day following its inauguration, more than 24,000 passengers were carried at 160 reis, a little less than two cents, per trip.

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## G. A. Mills

**George Arthur Mills** was born July 5, 1885, in Buchanan County, Iowa. Pursuit of his early education carried him through the East Waterloo, Iowa, high school (1903) to the Iowa State College at Ames, whence he graduated in 1909 with the degree of Bachelor of Science in electrical engineering.

Subsequent to his graduation from college, he served an apprenticeship course with the Allis-Chalmers Manufacturing Company at its works in Cincinnati, Ohio. From that activity he went to Philadelphia where he served the University of Pennsylvania as instructor in electrical engineering (1910-11).

Leaving his educational pursuits, he became in succession: electrical engineer for the Waterloo, Cedar Falls and Northern Railway Company at Waterloo, Iowa, (1911-17); electrical engineer for the Winnipeg Electric Railway Company, Winnipeg, Canada (1917-19); general superintendent for the Wisconsin division of the Northern State Power Company, at Eau Claire, Wis. (1919-24); vice-president and general manager of the Kewanee Public Service Company, Kewanee, Ill. (1924-26); chief engineer of the Central and South West Utilities Company, and vice-president of the Pecos Valley Power & Light Company, both of Dallas, Texas (1926-to date).

Mr. Mills became a Member of the Institute in 1918, and was a charter member and first chairman of the Dallas Section of the Institute, which was formed June 2, 1928.

## C. R. Higson

**Charles Roy Higson** was born in Salt Lake City, Utah, August 29, 1893. After having completed his preliminary education in the grammar and high schools of Salt Lake City, he entered the University of Wisconsin, whence he graduated in 1907 with the degree of Bachelor of Science in engineering. In 1912 he was awarded the degree of Electrical Engineer.

During the period 1907-1908 Mr. Higson was with the General Electric Company, at Schenectady, in the test course. In 1909 he returned to the University of Wisconsin as instructor in electrical engineering, where he remained until 1912, when he entered the employ of the Utah Power and Light Company. He has been with that company continuously since then, holding the positions of engineering assistant (1913-18) assistant engineer (1918-25), and finally taking his present position of superintendent of distribution in 1925.

Mr. Higson became affiliated with the Institute in 1921, and has served as chairman of the Utah Section, and as chairman of the Pacific Coast convention committee (1926). He has taken a prominent part in engineering activities in Salt Lake City, and served in 1930 as president of the Engineering Council of Utah.

## G. A. Kositzky

**Gustav Adolph Kositzky** was born April 20, 1879, at Yankton, South Dakota. His early education was obtained in the Yankton and Niobrara (Neb.) public schools. Subsequently he spent four years at the University of Nebraska and then two years at Cornell University, graduating in 1905 with the degree of Mechanical Engineer in electrical engineering. He then entered the employ of the New York and New Jersey Telephone Company at Brooklyn, N. Y., in construction and engineering work. In 1907 he was promoted to construction engineer and during the following two years engineered the rebuilding of the outside distributing plant in that city. Following this, he was loaned (1910) to the Pacific Telephone and Telegraph Company in charge of plant engineering work covering the larger cities along the Pacific coast.

In 1911 he was transferred to the South Western Bell Telephone Company. From that date up to 1919 he filled the positions of plant engineer, general plant superintendent, and general engineer. In this latter position he was in charge of valuation work in connection with several large rate cases in Missouri, Kansas, and Texas.

In 1919 Mr. Kositzky was appointed chief engineer of the Central Union Telephone Company operating in Illinois, Indiana, and Ohio with headquarters in Chicago. In 1921 he became the chief engineer of the Ohio Bell Telephone Company with headquarters at Cleveland, the position he now occupies. For the next several years he directed the engineering work in connection with the unification of telephone service throughout Ohio which came about through the merging of the Bell and independent companies. This presented the largest engineering problem in connection with the unification of telephone service in telephone history.

Mr. Kositzky became a Member of the Institute in 1922 and was transferred to the grade of Fellow in 1929. During this period he has been active in Institute matters and has served as a member of various committees both local and national, the latest as chairman of the communication committee during the years 1929 and 1930. At present he is chairman of the Cleveland Section. Also he has served the Cleveland Engineering Society as trustee, vice-president, and president (1928). He is a past-president of the Nebraska Club of Cleveland; is a member of the Cleveland Chamber of Commerce and of several social and athletic clubs.

### A. H. Lovell

Alfred Henry Lovell was born in Hamilton, Ontario, Canada, July 13, 1884. His early education was obtained in the public schools of that city and in the Collegiate Institute at Niagara Falls. He received his degree of Bachelor of Science in electrical engineering from the University of Michigan in 1909 and his Master of Science degree from the same institution in 1914. He has had a varied experience in design and construction of power generation projects, having served on the engineering staffs of such organizations as the Ontario Power Company (1902-5), the Telluride Power Company (1906), the Rochester Railway & Light Company (1909-10), and the Gladwin Light & Power Company (1912). He has been on appraisal work with the Detroit Edison Company, the Mexia Power & Light Company, and others and on rehabilitation design of the Kansas City Railways plant. He was with Muralt & Company (1910-11), transmission line contractors for the Hydro-Electric Power Commission of Ontario.

During the war Professor Lovell served in the United States, England, and France as Colonel of Engineers with the 310th Engineers, (Michigan-Wisconsin) and later commanded the Third Engineer Training Regiment at Camp Humphreys, Va.

After serving since 1911 as an instructor he was appointed (1919) professor of electric power engineering at the University of Michigan, and in 1929 was appointed assistant dean of the College of Engineering, both of which positions he now holds. He is a member of Tau Beta Pi, Sigma Xi and Phi Kappa Phi. Professor Lovell has written for the Michigan Technic and is the author of a text "Generating Stations."

Professor Lovell became affiliated with the Institute in 1912 as an Associate, transferring to the grade of Member in 1913. He has served as secretary-treasurer, vice-chairman, and chairman of the Detroit-Ann Arbor Section, and now is a member of the Institute's committees on education and power generation. Also he is a member of the N.E.L.A. (Great Lakes Division) committees on overhead, and underground systems, and chairman of the committee on electrical engineering of the Society for the Promotion of Engineering Education.

### A. C. Stevens

Alexander Chilson Stevens was born in Riverhead, Long Island, N. Y., October 9, 1883. After early schooling in Middletown, Conn. and White Plains, N. Y., he spent two years at Wesleyan University and three at Cornell. He graduated from the latter in 1907 with the degree of Mechanical Engineer in electrical engineering. After graduation he taught for several years, first at Wesleyan as instructor in descriptive geometry and physics, and later as instructor in electrical engineering at Cornell.

In 1917 Mr. Stevens joined the staff of the transformer engineering department of the General Electric Company in Pittsfield, Mass. In 1925 his interest in educational matters resulted in his being placed in charge of the sale of apparatus to educational institutions for his company, with headquarters in Schenectady, New York.

Mr. Stevens has been actively interested in A.I.E.E. matters since joining as an Associate in 1918. At Pittsfield he was, for some years before moving to Schenectady, a member of the executive committee of the local Section; successively chairman of several of the important standing committees, secretary, and vice-chairman-elect.

When the North Eastern District of the Institute was organized in 1922, he was chosen by Vice-President G. Faccioli to serve as district secretary, a position he has held ever since. The experience gained in planning the pioneer regional meeting at Worcester, Mass., and other early district activities was of great help to the Institute in formulating a definite policy with regard to other districts. In 1930 he accompanied President Harold B. Smith on an extended trip to Institute Sections in the Middle Eastern, Southern, and South Western Districts, going as far south as Mexico City.

Mr. Stevens is a member of the Society for the Promotion of Engineering Education, the Cornell Club of New York, Eta Kappa Nu, Delta Kappa Epsilon, and several Masonic fraternal organizations.

## Engineers Condemn Bidding for Services

The practise of publicly soliciting bids from engineers and the responding to such invitations was condemned severely in the following resolution adopted some months ago by the American Society of Civil Engineers:

"Whereas, the Council of the American Institute of Consulting Engineers has been asked to give consideration to the practice, occasionally followed by certain public officials and some corporations, of soliciting from engineers bids for rendering engineering services; and

"Whereas, the Council is firmly of the opinion that, in the award of engagements for engineering services, the element of the price paid for such services is one of the least of several considerations which should receive weight in the determination of the award. Among those other considerations of the relative suitability of the several engineers under consideration for engagement are, their personal integrity and strength of character; their executive and administrative ability; the character, extent and variety of their professional experience; their general standing in the profession and before the public, etc., etc., and, lastly, the compensation expected; and

"Whereas, members of the engineering profession who respond to public invitations to submit bids for rendering engineering services, thereby:—

(a) Promulgate, encourage and dignify the above undesirable and objectionable practice;

(b) Lower their individual and professional reputation and standing; and

(c) Tend to bring indignity and discredit on an honorable profession, therefore,

"Resolved, that the Council of the American Institute of Consulting Engineers:

1. Strongly condemns the practice on the part of some public officials and corporations of publicly soliciting bids from engineers for the rendering of engineering professional services;

2. Expresses its strong disapproval on the part of engineers, and particularly on the part of Members of the American Institute of Consulting Engineers, of the practise of responding to such invitations to submit bids for their professional services;

3. Records its sincere belief that the above practices of extending and accepting invitations to submit bids for the rendering of engineering services are certainly not in keeping with the elements of professional character and dignity which should—and in large measure do—at present characterize and control the engineering profession, and which form most essential and important elements of the foundation on which the American Institute of Consulting Engineers is established."

Upon recommendation of the Institute's committee on code of principles of professional conduct, the board of directors of the Institute on December 4, 1931 adopted the following resolution:

Resolved, that the board of directors of the American Institute of Electrical Engineers hereby endorses in principle the resolution adopted by the American Institute of Consulting Engineers, June 4, 1930, condemning the practise of advertising for bids for engineering services, and

Resolved, further, that the board of directors urges members of the A.I.E.E. to oppose this practise, and to give their active support to suitable methods of emphasizing the importance of selecting engineers on the basis of their qualifications for the work under consideration.

## Report Submitted on Illumination Congress

The report of the United States national committee of the International Commission on Illumination for the year ending November 1931 has been submitted by the president, E. C. Crittenden (A'19-M'22). Representatives of the Institute on this permanent committee are: A. E. Kennelly (A'88-F'13-Life Member and past-president); C. O. Mailloux (A'84-F'12-Life Member and past-president); and C. H. Sharp (A'02-F'12). Following are excerpts from this report:

Among the activities of the committee the outstanding events of the year have of course been the session of the International Commission held at Cambridge, England, September 13-19, 1931 and the International Illumination Congress which preceded the commission sessions. . . .

Technical sessions of the congress were held in Glasgow, Edinburgh, Buxton (in connection with Sheffield) and Birmingham, England.

It is impracticable to summarize the proceedings of the congress and the commission in any brief statement. In both cases many parallel sessions were held; 23 technical meetings were scheduled for the congress; 22 specialized and 3 general sessions were listed for the commission, and in addition there were numerous committee meetings and special conferences. . . . Reports (of these sessions) were presented in October 1931 by Mr. G. H. Stickney (A'04-F'24) and other delegates at the Pittsburgh meeting of the Illuminating Engineering Society, and it is hoped that a composite report based upon these may be published so as to be generally available. The full report of proceedings of the congress will be a bulky document; it is understood that copies will be supplied gratis to those who registered as members, and will be available for purchase by others.

At the sessions more than 100 papers by individual authors were presented in addition to the committee reports prepared under the 18 secretariat projects which constitute the major activities of the commission. . . . Contributions from the United States included 9 individual papers and 4 secretariat committee reports.

As to the value of the results of such an international gathering, it is difficult to form a definite opinion. Undoubtedly the sessions with the publicity which accompanied them helped to create in Great Britain a general appreciation of the value of good lighting and of the artistic values of special lighting. . . . In the more technical fields, properties of materials and methods of measurement, undoubtedly the sessions helped to promote uniformity of practise facilitating interchange of data. Definite progress was made also toward unification of practise in aviation lighting and the dimensions of lamp bases and sockets, the latter being a project of the International Electrotechnical Commission with the I.C.I. invited to collaborate. . . .

The next plenary session of the commission is scheduled for 1934; an invitation from the German national committee to meet in Berlin was accepted. . . . With regard to plans for the 1934 session, the American delegates urged that effort be made to concentrate upon a limited number of subjects and to have those subjects treated in a manner adequate and appropriate for an international meeting. . . .

For the use of those who may wish to consult the papers presented before the proceedings are issued, complete files have been placed in the office of the Illuminating Engineering Society in New York City.

# Electricity in Modern Medicine Discussed Before New York Electrical Society

A MOST SUCCESSFUL meeting devoted to electricity in modern medicine was held by the New York Electrical Society, December 16, 1931, in the Engineering Auditorium, New York, N. Y. L.A. Coleman is president of this society and E.E. Dorting (A'13-M'22) is secretary. Dr. Howard Kelly, emeritus professor of gynecology at The Johns Hopkins University, Baltimore, Md., presided at the meeting and gave a short history of the subject.

The first speaker was Dr. G. Failla, physicist of the Memorial Hospital, New York, N. Y., who discussed "Physical Advances in the Treatment of Cancer by X-Rays." Doctor Failla described the method by which the cancer patient is exposed to x-ray radiation continuously 24 hr. a day for periods up to two weeks. The radiation is secured from a 900,000-volt Coolidge tube which for clinical work is operated at 700,000 volts with a current of 5 milliamperes. Under these conditions the tube can be operated continuously for several hours without trouble, and gives a radiation emission equivalent to that of 450 grams of radium costing more than $22,000,000. Various other X-ray tubes also are being used in the experiment. At present it is not possible to predict the outcome of this investigation. The important biological effects produced by these high voltage X-rays at any given point in the body are being evaluated, however, and it is hoped to determine conditions producing the best clinical effects.

## ARTIFICIAL FEVER

The second speaker, Dr. C. F. Tenney of the Fifth Avenue Hospital, New York, N. Y., discussed the use of short wave radiation in raising the internal temperature of a patient. The equipment producing this fever consists essentially of a short wave radio machine having two plates between which the patient is placed. The resistance of the body to the short wave passing between the plates produces a rise in temperature particularly in the liver, kidney, spleen, heart, and muscles, so that without harm to the patient, the body temperature can be elevated from 98.6 to 104 and 105 deg. fahr., in from 60 to 80 minutes. The fever produced is followed by a sweat without initial chill, and is much more comfortable than other methods of producing fever. It is hoped that the method will be of lasting benefit in the treatment of rheumatism and diseases of circulation.

Doctor Tenney then described a portable equipment used for the production of localized heating, such as in the knee, ankle, or other small portions of the body, without producing a complete fever. The heater consists of a vacuum-tube oscillator and a full wave rectifier which supplies the high voltage for the oscillator. The high frequency oscillator consists of two pliotrons operating at a frequency of from 10,000,000 to 14,000,000 cycles, the output of 200 watts being concentrated between two plates. The rectifier, an oil-immersed transformer having a 4,500-volt secondary and feeding two half-wave hot-cathode mercury-vapor tubes, furnishes the 2,000-volt d-c. supply for the oscillator. A rheostat is connected in the primary circuit of the high voltage transformer to provide plate voltage regulation.

The condenser plates are of thin aluminum, 10 in. in diameter, and are covered with hard rubber plates 12 in. in diameter to prevent arcing should the patient or attendant come in contact with them. In the field of undamped waves between the plates there is a rapid alternation with a 2,000-volt drop in potential. The greatest heating consistent with tube output has been obtained from the use of a 30-meter wave, oscillating 10,000,000 times per sec. between plates.

## ELECTROSURGERY

A summary of the history of high frequency currents in medicine was given by Dr. G.E. Ward of The Johns Hopkins Hospital, Baltimore, Md. and instructor of surgery, University of Maryland. The physics of high frequency currents was discussed with special attention to the biophysical changes wrought in living tissue by the passage of so-called medical diathermy and electrosurgical high frequency currents. Diathermy currents are those which raise the temperature of a part or the whole of the body within physiological limits, while electrosurgical currents raise the local temperature well above that which is destructive to the cells. This destruction with related factors makes possible the use of such current in the eradication of tumors and other diseased tissues. Further attention was given by Doctor Ward to electro-cutting which has come into vogue in recent years for the removal of diseased areas.

## THE ELECTROCARDIOGRAPH

The meeting was concluded with a discussion of the electrocardiograph by Dr. H. Williams, professor of physiology at Columbia University, New York, N. Y.

Doctor Williams told of the physical aspects of the electrocardiograph, and discussed the advantages of this equipment which is an important factor in the modern diagnosis of heart disease. The equipment makes use of the variation in electric current accompanying the contraction of the heart, and an instrument has been developed which is sufficiently sensitive and quick to follow the small and rapid changes in the movement of this organ.

## A.S.M.E. Holds Annual Meeting

Economics shared honors with engineering as a subject of major interest at the fifty-second annual meeting of The American Society of Mechanical Engineers, held in New York, N. Y., November 30 to December 4, 1931. While the registration, approximately 2,000, fell somewhat behind that of last year, there was no falling off of interest and significance nor in the broad extent of the program. Statistics indicate that there were scheduled some 25 technical sessions, 72 committee meetings, with 80 technical papers and reports presented, in addition to 6 special lectures and numerous other activities of a social and professional nature.

Regarding the election of officers for 1931-32 announcement was made as follows: *President,* C.N. Lauer; *vice-presidents,* R.M. Gates, C.M. Allen, F.H. Dorner, and W.B. Gregory; *managers,* A.J. Dickie, E.W. O'Brien, and H.R. Westcott; *delegates to American Engineering Council,* C.N. Lauer, Paul Doty (M'12), R.E. Flanders, C.E. Ferris, L.P. Alford, J.H. Lawrence (M'28), R.C. Marshall, Jr. (M'19), A.A. Potter, W.H. Trask, Jr. (A'12), and E.C. Hutchinson.

The sessions included many papers of undoubted value to electrical engineers, and it is hoped that space in future issues of ELECTRICAL ENGINEERING will permit the inclusion of a major portion of this information.

**Fellowship in Glass Founded.**—Announcement has been made of the establishment by the Macbeth-Evans Company of a fellowship in illuminating glassware at the Mellon Institute of Industrial Research, Pittsburgh, Pa. It is stated that the scientific investigations to be conducted will be a continuation along original lines and entirely independent of the technological research being carried on in the Macbeth laboratories. Dr. R.R. McGregor, a specialist in physical chemistry, has been appointed to the incumbency of this fellowship.

## Electricity to be Prominent in World's Fair

Extensive reservations for exhibit space in the electrical buildings of the 1933 World's Fair to be held in Chicago already have been contracted for by leading manufacturers of electrical equipment and supplies, producers of radios, and telephone and telegraph companies which provide the nation's principal communication facilities. The electrical group now is being erected on Northerly Island which adjoins the mainland at the fair site on Chicago's lake front; it is composed of three units: the electrical building, the communication building, and the radio building. (See ELECTRICAL ENGINEERING, V. 50, p. 762, Sept. 1931.)

Space on the first floor of the electrical building will be devoted to demonstrations of manufacturing processes; the second floor has been reserved for displays depicting the development of electrical engineering and electrical illumination. Connecting with the electrical building on the north is the communications building, all space in which already has been contracted for by leading telephone and telegraph companies; their exhibits will tell stories of the discovery, invention, and perfection of modern wire communication. At the extreme northern end of the group is the radio building. Exhibits already planned for this section will demonstrate how radio branched off from two-way communication and became the marvelous news and entertainment feature which it now is. In this building also it is expected to stage a broadcast sponsored by the two leading radio chains to demonstrate how programs of news, entertainment, and music are "put on the air."

In addition to the many attractive displays, stories of the epochal discoveries and inventions made in the field of electricity during the past hundred years will be told by men of vision and genius who are worthy successors to those who discovered and developed electric power. Thus in its entirety the electrical show is expected to be one of the most popular and spectacular features of the whole "Century of Progress" exposition.

**Engineering Studies Open to Unemployed.** Announcement is made by Dean J. W. Baker that classes in the engineering school of Columbia University have been opened to unemployed professional engineers. President Nicholas Murray Butler has sanctioned the measure after the proposal had been advanced by the professional engineers' committee on

## Hoover Dam Tunnels Near Completion

U.S. Bureau of Reclamation Photo

BEFORE excavation can be started on the foundation for Hoover Dam, four diversion tunnels each 4,000 ft. long must be completed. These tunnels (56 ft. diameter inside of rock, 3 ft. concrete lining) will divert the stream flow around the dam site. Downstream portals are shown above. The attack on these tunnels is from both upstream and downstream portals and from two additional faces in each tunnel opened by adits driven in from the canyon wall at about midpoint. More than 14,000 ft. of top heading has been completed, the two inner tunnels being holed through.

unemployment. Applicants must secure a certificate from the engineers' committee, showing that they are accredited members of the profession and are idle through no fault of their own. The number admitted will be limited by the size of the lecture halls only. By this means it is hoped to preserve morale during a period of enforced idleness, and to broaden the applicant's knowledge of engineering.

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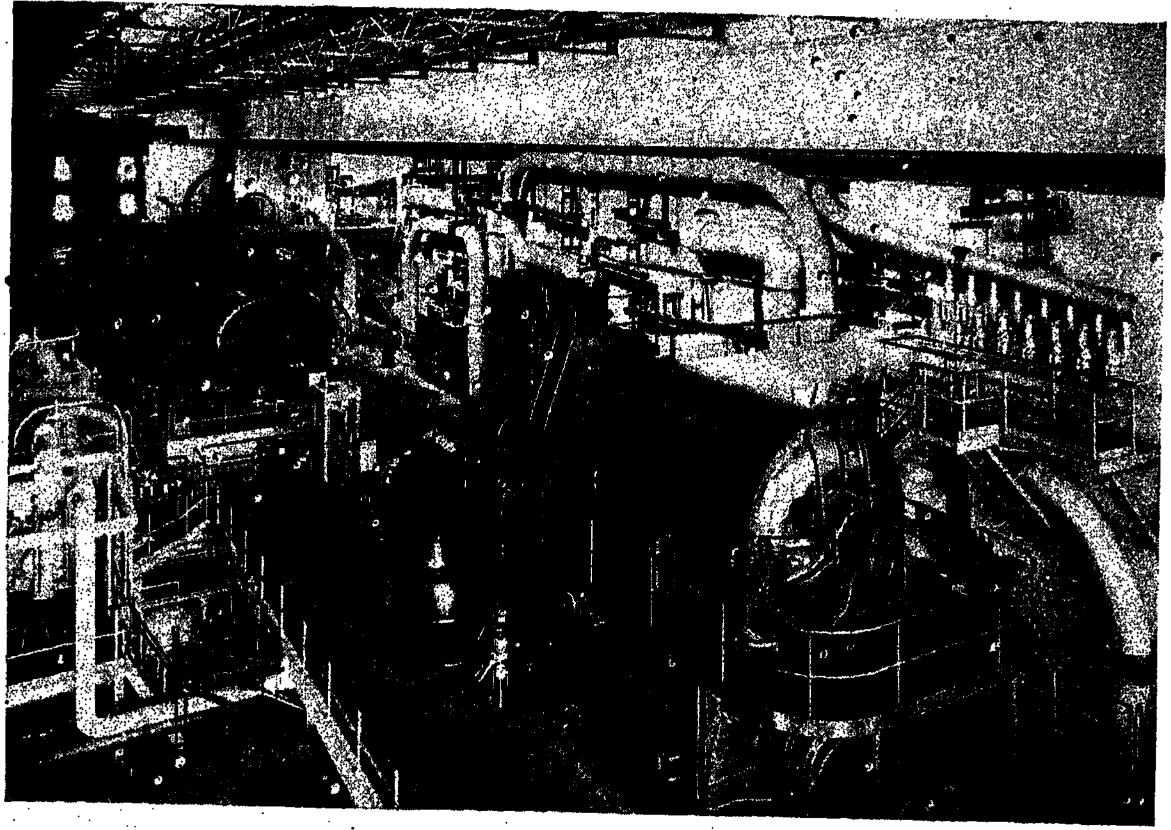
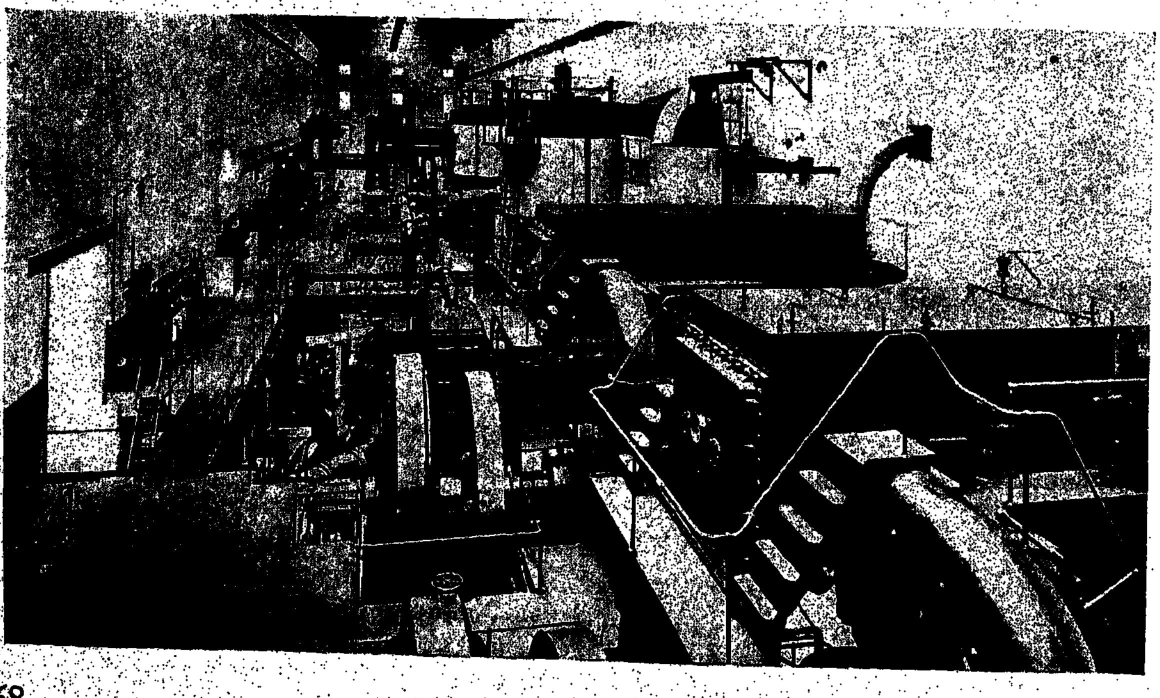
## 100,000 Kw. in Space Designed for 6,500



THE FIRST steam plant in the western states utilizing a boiler pressure of 1,400 lb. is station "A" of the Pacific Gas and Electric Company. The engine room of this plant, located in the center of the San Francisco industrial area, has had an interesting evolution. As constructed in 1901, it is 425 ft. long and 57 ft. wide; the original plant contained six vertical compound steam engines operating under 200-lb. pressure, and driving electric generators. By 1910 this equipment had been replaced by ten vertical reciprocating oil engines driving 1,500-kw. generators; by 1919, four 12,000-kw. turbo-generator units had replaced all but two of these engines, giving a plant capacity of 57,000 kw. This latter equipment, illustrated below, remained essentially intact until the most recent and perhaps the most striking change was made, when the two 50,000-kw. turbo-generator units shown above replaced two of the older turbo-generator units and two of the engine driven units. The same floor space required for 6,500 kw. in 1902 now contains equipment rated 100,000 kw. The steeple-compound units with the high-pressure turbine directly over the low-pressure one have not required even an increase in headroom.



## American Institute of Physics Organized

Formal announcement has been made of the organization of the American Institute of Physics established by the American Physical Society, the Optical Society of America, the Acoustical Society of America, and the Society of Rheology. The new institute will serve the four societies mentioned, and through them, physics in general in matters of common interest, particularly in their relation to other societies and to the public. The board of management consists of Karl T. Compton, chairman, and G. B. Pegram, secretary. H. A. Barton is director, and J. T. Tate, advisor on publications.

The membership of the four societies establishing this institute includes a majority of the active physicists in the country, whether interested in pure or applied physics and whether filling university or industrial positions. This large group has felt first the need for unification of effort, and second for the existence of an agency which would perfect details of organization and co-operative publication of physics journals; also to assist the newspapers to disseminate accurate news of important developments and applications of physics. The value of these aims is obvious and it is also obvious that they do not conflict with the aims of any already constituted agency. It is indeed to be expected that those agencies of service to science already operating will find their scope and activities increased through the work of this institute.

## "E.E." Offers Index and Binding Service

The annual index covering the contents of ELECTRICAL ENGINEERING for the twelve issues of the calendar year 1931 will be available for distribution after January 15, 1932. It is to be published in a form convenient for those wishing to file it for reference or to include it in bound volumes of the 1931 monthly issues. A notice of this index appeared in the advertising section of ELECTRICAL ENGINEERING for December 1931 and is repeated in this issue. An order form may be found on p. 992 of the December issue. The index will be printed in a quantity governed by the number of requests received prior to January 15, 1932.

The advertising pages for December 1931 included also the notice that binding service for the 1931 copies of ELECTRICAL

ENGINEERING now was available at cost. Upon shipment of the copies to the order department of the Institute, they will be bound neatly and durably, and returned prepaid. Full details are given in the advertising section of this issue and an order form appears on p. 70.

## Consulting Engineers Denounce Free Engineering

The American Institute of Consulting Engineers, at the October meeting of its council, accepted a report of its committee on professional practise and ethics protesting against the furnishing of engineering plans and specifications by manufacturers and distributors of equipment and materials. The committee reported:

"The attention of the council of the American Institute of Consulting Engineers periodically has been called to the practise, on the part of large manufacturers and distributors of equipment and materials, of making investigations, engineering plans, and specifications for architects and owners, involving the use of equipment and materials which they sell, all apparently without charge or for a nominal charge.

"On at least two specific occasions the attention of the officials of several of the largest manufacturing concerns has been called to such practise without any apparent lasting results.

"The field of the professional engineer, engaged in private practise, constantly is being invaded by manufacturing concerns, both large and small, through the medium of offering to the prospective purchasers of their products of manufacture free consulting engineering service.

"It is clearly evident that such offering is made for the single purpose of selling their particular articles of manufacture, thus restricting the purchaser to products which may or may not be standard and of the best quality. It is equally evident that such practise not only is vicious, from the standpoint of the engineer engaged in private practise, but deprives the purchaser of the judgment of an impartial expert whose only interest is the interest of his client."

The committee therefore offered the following resolutions and recommended their adoption by the I.C.E.:

"RESOLVED, that the American Institute of Consulting Engineers denounces the practise of designing and planning of engineering work by those who have interests other than the efficiency and effectiveness of the installation, as *highly unethical*, and

BE IT FURTHER RESOLVED, that the Institute (I.C.E.) use such means as its council and/or officers deem best to eliminate such unethical purposes."

Copies of the report and notices of the action taken have been sent to the presidents of several corporations throughout the United States.

# Letters to the Editor

## Progress is the Way Out of Depression

*To the Editor:*

Mr. Berresford's article "Progress is the Way Out of Depression" in the December 1931 ELECTRICAL ENGINEERING is good promotion talk and has an excellent sales appeal in tending to make each human being think that he accomplishes more than the foremost leader. It may be exactly the kind of talk we should have at the present hour; I have been following his advice for the past year. Yet his primary thesis appears to be in conflict with many an article that I have read in the last ten or twenty years and also with my own observation.

The first part of the fourth paragraph, for example, seems to conflict with fundamental facts, although it may agree with superficial ones. Many of us think that the daily effort of the millions, when it is good, comes from the effort of the outstanding few and only from that source; we think this in spite of the essential failure of the church to provide adequate leadership, because there are successful leaders even among those who do not profess to be leaders. History indicates that without the thinking and the leadership of a few, man has tended to revert rather than to advance, which is largely why we are honoring Faraday this year.

"Do your bit as best you can" is good advice now and always will be, except for perverts, but all men are created equal only before the law. Without true leadership man has retrogressed in the past and will presumably continue to do so in the future. Hence in reading Mr. Berresford's article it will perhaps be well to keep in mind the possibility that, in trying to drive home his worthy point, he may have overstepped the bounds of fact. The end may at times justify the means, unless the means manufactures a boomerang.

Very truly yours,
H. H. KETCHAM (A'13-M'23 and Life Member) (Technical Editor, Forest Products Lab., Madison, Wis.)

## Characteristics of Arc Welding Generators

*To the Editor:*

I acknowledge receipt of the paper by Mr. J. H. Blankenbuehler on "An Improved Arc Welding Generator." An article based upon this paper was published in ELECTRICAL ENGINEERING, August 1931, p. 666-8. The information contained therein is especially interesting to me as ten years ago I took a patent—No. 1,549,874—on the use of d-c. transformer in the welding and excitation self-circuits of any single-operator inherently—regulating arc welding generator.

The article explained many things to me that I did not understand before. However, my comments on his paper are that the statements regarding porosity being bettered by the welding machine and that freezing of the electrode is lessened by stopping the inrush of current are not agreed with by those people experienced in welding and are very misleading to others.

Freezing of the electrode is a phenomenon that is of no concern in welding because a good welder never freezes. Freezing or sticking is the earmark of an inexperienced or beginner welder. What is of some importance, however, is heating up the cold work as quickly as possible so the start of the weld is as well fused as the remainder. Welding, at present, is a compromise between too cold a start and too hot a finish. Porosity is caused by the latter—too hot a finish, and cold shots are caused by the former. It is very important to have the momentary rush at the starting as great as possible. Often a larger size sheet is used to effect this purpose. Sometimes tapered rods are used to offset this difference which obtains either in automatic or manual welding because all the heat that is in the arc, electrode or work, in the next instant is deposited in the work, which becomes hotter and hotter. Good welding consists of a compromise between how hot you can start without finishing so hot as to burn the metal, and judicious welding with invariably short lengths of electrodes have given the best results to date.

Furthermore, the curbing of the transient; that is, holding it below 200 per cent holds down the welding persistency. In other words, in chasing after this mechanical freezing of the electrode, the welding qualities are lessened. In other words, if you teach the machine to react quickly and then deliberately curb it, naturally both the properties of biting quick and holding back cannot be present under all conditions. You might be able to teach a dog to bite some people and not bite others but with a welding machine, I think it is quite impossible. So far, no one has discovered how to describe in technical terms this persistency of the arc but the difference between a machine that is curbed at 200 per cent and one that is allowed to react naturally with a time recovery of 2/10 of a second or less is the difference between Bobbie Jones or me or you.

Very truly yours,
O. J. HOLSLAG (M'19)
(President, Electric Arc Cutting & Welding Co., 152 Jelliff Avenue, Newark, N. J.)

## Has Man Benefited by Engineering Progress?

*To the Editor:*

The published introduction to the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?" very definitely emphasizes the "deeper effects" of engineering achievement and its spiritual consequences. Mr. Mees' thought provoking article and letters of comment by Messrs. Dreher and Johnson are stimulating contributions to the announced topic. The apparent straying or lack of definiteness in some of the subsequent articles is disappointing. Too much responsibility is thrown upon the reader to deduce the author's viewpoint on the larger questions at issue.

Mr. Insull, conceding a disadvantage to humanity due to the congestion of industry in the past, predicts an improvement in the future because of the widespread distribution of power. In stating these well known facts about power supply and distribution, the author seems to imply that on the whole man has not benefited in a broad way in the era just opening, for the reasons stated. On the other hand, we may do the author an injustice. Perhaps he intends to imply all has been well and satisfactory as a result of engineering developments in the past except the slight congestion of industry, and that little matter is well on the road to being corrected. A more definite commitment on the fundamental issues would have been welcome.

Mr. Grunsky emphasizes two principal points. First, a plea for the establishment of museums, art galleries, music conservatories, etc., as a stimulus for the spiritual uplift of the people. Second, a suggestion that these public improvements should be financed by new high rates of taxation, not, however, by the "prevailing unfair" system. As regards taxation, a great number of diverse theories have been proposed and many tried and discarded. Although engineers are (or should be) vitally interested in this topic, taxation has no more direct bearing on engineering progress and its effects than religion has. It is quite true, however, that not only taxation but religion and other institutions of our complex social order have an important effect on human welfare and happiness.

As regards the establishment of additional structures for spiritual uplift and public welfare, there are those who believe that not more edifices, but a more general acquaintance with the interiors of some already built (*e. g.*, places for worship) would better serve the purpose. However, this is beside the point. The responsibility of engineering developments is in no clear way indicated or even remotely suggested. The paper, indeed, is an excellent plea for the expansion of the fine arts as a basis for the spiritual uplift of the people. With this thesis the critic takes no exception, but manifestly the implied conclusion is, increase the number of artists, musicians, etc., but not the engineers. If the author had this conclusion in mind it would have been more satisfactory had he directly stated it. If he did not have this or a similar idea it is a little difficult to understand just how the paper fits into the symposium.

If the sponsors of these articles desire a general discussion of the fine arts, of religion, of psychology, of economics, of politics, etc., as well as of engineering progress, all of which have a direct bearing on happiness, there can be unlimited ramifications with but little coherence.

Yours very truly,

L. H. RITTENHOUSE (A'10)
(Professor of Engineering,
Haverford College, Haverford, Pa.)

## Nerve Injuries from Electric Shock

*To the Editor:*

The very interesting work done by W. B. Kouwenhoven and O. R. Langworthy as reported in the December 1931 issue of ELECTRICAL ENGINEERING takes into account the effects of direct-current and low-frequency alternating-current.

The undersigned has observed that theories on "electric shock" are gradually shifting from the purely physiological viewpoint to a more biological and physical one. It seems to him that the primary causes of injury are of either electrolytic or thermic nature, and physiological effects are the result of heating or electrochemical decomposition of cell contents. A strong support for this thought lies in the fact that high-frequency currents injure the living body only through heating.

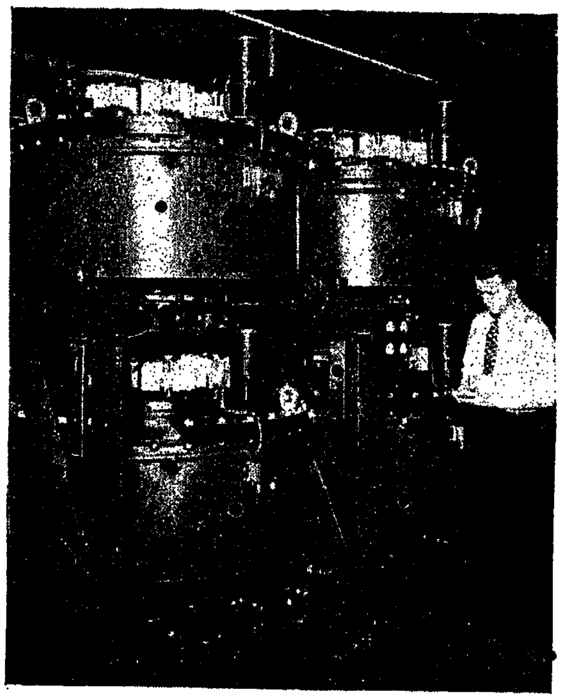
Lack of facilities so far prevented the writer from proving his theory experimentally. He believes that a continuation of the photomicrographic studies at The Johns Hopkins University with currents of higher frequencies will produce further interesting and valuable results.

Very truly yours,

KURT MAHNKE (A'26)
(401 Avenue D, Forest Hills,
Pittsburgh, Pa.)

## Mercury Arc Rectifiers of Sectional Construction

As the size of mercury arc rectifiers is increased, difficulties of design to secure satisfactory operation also increase greatly. Large units tend to be not only less reliable but actually less efficient than the smaller ones. To overcome these difficulties, there have been developed sectional rectifiers of the size which gives the best performance and so shaped that they may be placed together to form compact assemblies of any rating.


Westinghouse E. & M. Co. Photo

3,000-kw. rectifier made up of four 750-kw. sections

The 3,000-kw. rectifier unit illustrated consists of four interchangeable 750-kw. sections integrally mounted, fed from a single transformer, and easily withdrawn on rollers after the fashion of truck type switchgear. For this rating, the use of these sectional units results in a rectifier, each section of which is not only more reliable, but one in which a failure of one section does not involve complete shutdown of the entire group. Spare units may be provided easily. Piping and wiring are simplified, and both energy losses and space required are reduced by about one-third.

**American Scientific Congress Postponed.** Through the Pan American Union, word has been received from the Mexican Government announcing the postponement until November 1933 of the sessions of the Seventh American Scientific Congress, which was to have been held in Mexico City February 5-19, 1932. It was found that present world conditions make it impossible for many nations to send special representatives.

## Test Code for Transformers now Available

Pursuant to notice which appeared in the October issue of ELECTRICAL ENGINEERING (p. 844) giving publicity to effort on the part of the Institute's standards committee to develop test codes for electrical machinery and apparatus, this committee now has formulated a preliminary report on the proposed "Test Code for Transformers," pamphlet copies of which may be obtained without charge from A.I.E.E. headquarters, 33 West 39th Street, New York, N. Y.

# American Engineering Council

## N.J. Engineers Promote Public Works for Relief

A statewide plan of municipal improvement is sponsored by a New Jersey employment committee of the A.E.C. which has just been organized with Lynne J. Bevan of Montclair as chairman. The aid of the 2,800 licensed engineers and land surveyors in the state will be enlisted in shaping public works programs in every community.

These programs will be adjusted to a state plan, the legislature having provided that the state, to the limit of allotments, may meet dollar for dollar the money paid by local political units for labor or personal services. Tasks ranging from city planning studies to road and street repairs and the remodeling of public and semi-public buildings are suggested; elimination of grade crossings, widening and beautifying of streets, plans and estimates for future highways and parks are other objectives.

The members of the committee include: Governor Morgan F. Larson; Harvey N. Davis, president of Stevens Institute of Technology, Jersey City; L. P. Alford, Montclair, vice-president of The Ronald Press (N. Y.); Lincoln Bush, East Orange, past-president of the American Society of Civil Engineers; Dean P. H. Daggett (A'08) Rutgers University, New Brunswick; Charles A. Mead, chief engineer of the division of bridges and grade crossings of the New Jersey Public Utilities Commission; E. B. Meyer (F'27), Newark, vice-president, United Engineers and Constructors, Inc.

The committee also will work with the professional engineers unemployment relief committee organized in New York by the four Founder engineering societies to aid idle engineers throughout the whole New York metropolitan area. A New Jersey section of the latter committee has been formed with Louis A. Janny of the American Institute of Mining and Metallurgical Engineers as chairman.

The engineers, according to Chairman Bevan, purpose to stimulate legitimate construction work, and to avoid unsound projects. "The immediate objective upon which your action is requested," he said in an appeal to the engineers and surveyors, "is the bringing to light of sufficient necessary public project work in your vicinity, and the incorporation thereof in the official plan of your community which must be filed with the state director of emergency relief by December 1, 1931."

# Personal

## Edwin W. Rice, Jr. Awarded Edison Medal

Dr. Edwin Wilbur Rice, Jr., has been awarded the A.I.E.E. Edison Medal for 1931 "for his contributions to the development of electrical systems and apparatus and his encouragement of scientific research in industry." The Edison Medal was founded by associates and friends of Thomas A. Edison, and is awarded annually for "meritorious achievement in electrical science, electrical engineering, or the electrical arts" by a committee consisting of 24 Institute members.

Doctor Rice is one of the pioneers of electrical development in the United States and has played a conspicuous part, in association with the late Charles A. Coffin, in the building of the present General Electric Company. As a schoolboy in Philadelphia he came in contact in 1876 with Prof. Elihu Thomson, then a young teacher in the Boys' Central High School. When in 1880 the professor gave up teaching to go into electrical manufacturing as scientist and inventor, young Rice gladly accepted an opportunity to become his assistant. He went with Thomson to New Britain, Conn., in the old American Electric Company, and in 1883 went with the professor to Lynn, Mass., upon the organization of the Thomson-Houston Electric Company. At the age of 22 he was made plant superintendent and had this full responsibility until the consolidation of the Thomson-Houston Electric Company and the Edison General Electric Company in 1892, under the name of General Electric Company.

In the new company Doctor Rice first was made technical director, then vice-president in charge of manufacturing and engineering. Eventually he became senior vice-president and, in 1913, he succeeded Mr. Coffin as president of the company. In 1922, after nine years' service in that office, he was succeeded by Gerard Swope. Doctor Rice at that time was made honorary chairman of the board, which position he still holds. He has contributed much through organization methods, improved factory routine, technical development, and engineering and scientific inventions to the prominence attained by the General Electric Company. His degrees are: Honorary A.M., Harvard (1903); Sc.D., Union University (1906); Doctor of Engineering, Rensselaer Polytechnic (1917); Sc.D., University of Pennsylvania (1924).

E. W. RICE, Jr.

He is a past-president and Fellow of the Institute, and a Chevalier Legion d'Honoeur of France. In 1917 he was decorated by the emperor of Japan with the Third Order of the Rising Sun with Cordon. He invented the present fundamental form of high-voltage oil switch and the cellular system of separating buses and circuits; as well as the application of synchronous converters to the building of unified a-c. and d-c. distribution systems. He was responsible for the adoption by his company of the Curtis steam turbine, and for the establishment of the company's research laboratory. He has endorsed and promoted many modern forms of industrial organization and of methods of advancing employees' welfare.

As a recipient of the Edison Medal, Doctor Rice shares the honor with: Elihu Thomson, Frank J. Sprague, George Westinghouse, William Stanley, Charles F. Brush, Alexander Graham Bell, Nikola Tesla, John J. Carty, Benjamin G. Lamme, W. L. R. Emmet, Michael I. Pupin, Cummings C. Chesney, Robert A. Millikan, John W. Lieb, John White Howell, Harris J. Ryan, William D. Coolidge, Frank B. Jewett, Charles F. Scott, and Frank Conrad.

A. B. Campbell (A'19) after thirteen years of service with the General Electric Company's Fort Wayne (Ind.) plant, where he was intimately connected with various developments of demand meters, thermal relays, timing devices, and allied equipment for the meter and fractional horsepower motor departments, is now chief engineer for the Seth Thomas Clock Company, Thomaston, Conn. While in Fort Wayne, Mr. Campbell served the A.I.E.E. as both secretary and chairman of its Fort Wayne Section.

Bancroft Gherardi (F'12) was reelected president (1932) of the American Standards Association at its annual meeting held in New York City December 9, 1931. Mr. Gherardi is vice-president and chief engineer of the American Telephone & Telegraph Company (N. Y.); active in Institute affairs, he has served prominently as president (1927-8) vice-president (1908-10) and manager (1905-8 and 1914-17).

G. N. Brown (M'21) who formerly was associated with the New York office of the Ohio Brass Company, sales department, now has joined the commercial staff at N.E.L.A. headquarters, as manager of its electric refrigeration bureau. Mr. Brown's service with the Ohio Brass Company extended over a period of four years as district manager, first of the Philadelphia office, and then of the New York office.

J. C. Parker (F'12) was reelected December 9, 1931, at the annual meeting of the American Standards Association to serve (1932) as vice-chairman of the Standards Council. Mr. Parker is vice-president in charge of engineering for the Brooklyn (N. Y.) Edison Company; he has served the Institute in several capacities including that of vice-president (1921-2).

J. A. Foley (A'31) from 1923 to 1930 in the engineering design, application, and sales departments of the General Electric Company in both Cleveland and Toledo, Ohio, in the latter location serving also as engineering consultant over a period of approximately two years, recently became an electrical engineer of the Worthington Pump and Machinery Corporation in Chicago, Illinois.

P. J. Wilson (M'12) formerly sales manager of the Narragansett Electric Company, Providence, R. I., recently resigned to become vice-president and treasurer of the New England Branch of Kaslin & Company, Inc., with main offices in Syracuse, N. Y. Mr. Wilson's headquarters, however, will be in Providence.

K. W. Johansson (M'28) formerly serving the Westinghouse Electric and Manufacturing Company as an electrical engineer at the East Pittsburgh plant, now is special representative covering oil fields and other industries in Venezuela, Columbia and other South American countries for the Westinghouse Electric International Company.

R. S. Eininger, Jr. (A'29) who has been serving the General Electric Company, Erie, Pa., as cost engineer now has joined the company's force at Pittsfield, Mass., in the manufacturing general department. Mr. Eininger was student secretary of the Drexel Branch during the year 1926-27.

Clyde Treon (A'28) for some time past distribution superintendent of the Pernambuco Tramways & Power Company, Pernambuco, Brazil, South America, has returned to the United States and is serving now in like capacity with the West Penn Power Company, Pittsburgh, Pa.

Fraser Jeffrey (F'24) electrical engineer with the Allis-Chalmers Manufacturing Company, West Allis, Wis., recently was elected vice-president of the Engineers' Society of Milwaukee, of which he has been a member since 1907 when he started his career in the electrical industry.

J. C. Van Horn (M'28) has been made a vice-president of the R.C.A. Institutes, Inc., Philadelphia, Pa., and will have charge of resident schools at Philadelphia, New York, Chicago, and Boston. Mr. Van Horn has been serving the R.C.A. Institutes as general superintendent.

Winthrop Allen (A'30) has changed his work as assistant electrical engineer of E. I. duPont de Nemours Company, Wilmington, Del., to associate himself with the Prudential Insurance Company, Newark, New Jersey, as electrical engineer of home office buildings.

Paul S. Clapp (A'18) until recently managing director of the National Electric Light Association, New York, N. Y., resigned from that office to become vice-president of the Columbia Gas and Electric Corporation, with offices at its headquarters in New York City.

E. G. Waters (A'90) who has completed a record of more than 42 years of continuous service with the General Electric Company, and for the past 25 years has been secretary of its sales committee at Schenectady, N. Y., now at his own request has been retired.

E. J. Verrier (A'28) recently serving as electrical engineer of the Engineering Equipment Company, Montreal, Can., now has been made power plant superintendent for the Anglo Newfoundland Development Company, Grand Falls, Newfoundland.

S. R. Barrett (A'28) who in the past has been associated with the Hemenway Electric Corporation, Springfield, Vermont, now is station operator for the Turners Falls Power and Electric Company, Gobble Mountain Station, Westfield, Mass.

C. H. Willis (M'28) who since 1926 has been assistant professor of electrical engineering, Princeton University, Princeton, N. J., now has become associate professor in the electrical engineering department of the university.

B. S. Anderson (A'30) manager of the Japan branch of the English Electric Company, Ltd., at Tokyo, now has been transferred to Shanghai, China, where his address will be in care of Jardine Engineering Corporation, Ltd.

J. T. Serduke (A'30) until recently a research engineer at the General Electric Company's laboratory, Schenectady, N. Y., has joined the department of physics, Massachusetts Institute of Technology, Cambridge, Mass.

T. R. Cook (M'16) who has been engineer of Coverdale and Colpitts, consulting engineers, New York City, recently was made service manager of the Baldwin Locomotive Works' Paschall station, Philadelphia, Pa.

Emerick Toth (A'29) formerly laboratory assistant, Kolster Radio Corporation, Newark, N. J. recently became receiver engineer of high frequency circuits for Wired Radio, Incorporated, Ampere, N. J.

Herbert Southworth (A'22) formerly merchandise manager for the Fall River Electric Lighting Company, Fall River, Mass., now is assistant manager of the North Adams Gas Light Company, North Adams, Mass.

G. G. Post (A'11) vice-president and chief electrical engineer of the Milwaukee Electric Railway & Light Company, Milwaukee, Wis., recently was elected a director of the Engineers' Society of Milwaukee.

H. A. Luedeke (A'29) has joined the National Broadcasting Company, New York, N. Y., as monitoring engineer. His previous work was with the Western Electric Company, at Kearny, N. J., as design engineer.

M. B. Karelitz (A'27) who has been an engineer at the Westinghouse Electric and Manufacturing Company's main plant, East Pittsburgh, Pa., now has been transferred to the company's East Springfield works.

John Egli (M'26) who has been manager of service and erection for the American Brown Bovari Electric Corporation, now is with the Allis Chalmers Manufacturing Company, Milwaukee, Wis.

M. G. Lord (A'22) who since 1907 has been in the ranks of companies affiliated with the Southern Colorado Power Company, Pueblo, Colo., now is vice-president in charge of operation for that company.

O. B. Parker (A'29) for the past four and a half years assistant chief engineer of the Pacent Electric Company, Inc., New York, N. Y., has been promoted to the position of chief engineer.

J. W. West (M'28) who has been manager of production for the R.C.A-Victor Corporation at Camden, N. J. now has joined Frozen Confections, Incorporated, Maplewood, N. J.

H. P. Currin, (M'30) electrical engineer of the Eugene water board, Eugene, Ore., now has been appointed electrical engineer of the State board of engineering examiners of Oregon.

H. A. Faesi (A'27) serving in the past as an electrical engineer, for Allied Engineers, Incorporated, Atlanta, Ga., now has joined the Georgia Power Company in that city.

## Obituary

Howard Rankin Sargent (A'96-M'12 and Member for Life) engineer of the merchandise department of the General Electric Company, Bridgeport, Conn., died suddenly at his home in that city, December 8, 1931. The relapse followed an operation for appendicitis. Mr. Sargent was sixty years of age and a native of Newton, Mass. He was graduated from Massachusetts Institute of Technology in 1893, and promptly thereafter entered the employ of the old Thomson-Houston Company at Lynn, Mass. There he remained, with the exception of an interval during which he was working at Marlboro, Mass., until in 1894 many of the Lynn engineers were transferred to Schenectady. When the merchandise department of the company was organized in 1922, Mr. Sargent was transferred to Bridgeport as manager of the wiring supplies engineering division. In 1926 he was made engineer of the merchandise department. In the course of his professional career, Mr. Sargent has been credited with many important electrical inventions. He also was active in the National Electric Light Association and the National Electric Manufacturers Association.

Joseph Walter Miles (A'02) for many years in charge of foreign engineering for the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and recently appointed consulting engineer to the foreign and development information bureau, died suddenly November 28, 1931. Mr. Miles had been a member of the Westinghouse organization for thirty-seven years, and lacked only six years' membership to qualify as a Member for Life of the Institute. He was still a resident of Irwin, Pa., where he was born July 20, 1870. As a student of archeology had made several investigations of that vicinity and was the author of a book "The Sewickley Indian," describing an ancient tribe of Pennsylvania. He studied at the University of Pennsylvania and Cornell University, and from the latter obtained his M.E. degree in 1893. For two years he was with the Westmoreland Coal Company, following which he commenced his long service with Westinghouse.

William Isaac Donshea (A'03-M'13) retired, died December 21, 1931. Mr. Donshea was born in New York City August 2, 1858. After completing his education, Mr. Donshea's first position was with the New York Telephone Company as operator and inspector in 1879-80, which position he left to become electrician and general superintendent, installing telephone exchanges in South America for the Telephone Company of Brazil from 1880 to 1887. During the years 1882-5 he also assisted in installing an Edison exhibition "electric" plant at the National Industrial Exhibition in Rio de Janeiro; a Thomson-Houston exhibition electric plant in Rio de Janeiro, and an Edison-Swan electric light plant in a Brazilian industrial mill. Following this and up to 1929 Mr. Donshea was an operating electrician and a district operating superintendent with the New York Edison Company. In 1929 he retired from active service after 50 years in the electrical industry.

# Local Meetings

## Future Section Meetings

**Akron**

Jan. 12—X-Ray Inspection of Welds, by Ancel St. John, pres., St. John X-Ray Service Corp. Movies: "Story of Steel." Meeting to be held in the auditorium of the Ohio Edison Co.

Feb. 9—At 4:00 p.m. inspection trip through the Ohio Edison Company's East Akron substation. At 7:45 p.m. movies: "Through Oil Lands." At 8:15 p.m. James H. Foote, Allied Engineers, Inc., will speak on Load Shifting Transformers at Salt Springs. Meeting to be held in the auditorium of the Ohio Edison Co.

**Chicago**

Jan. 7—Control of Noise and Vibration in Station Design, by P. E. Stevens, Byllesby Engg. and Mgmt. Corp.

Feb. 10—Modern Underground Cable Practise, by Herman Halperin, Commonwealth Edison Co.

**Cleveland**

Jan. 21—Some Institute Problems, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co.

Feb. 18—Lightning—Recent Investigations and Findings, by K. B. McEachron, Genl. Elect. Co., Schenectady, N. Y.

**Dallas**

Jan. 18—General Developments of 1931, covered by engineering students of the Southern Methodist Univ. Student Branch.

**Detroit-Ann Arbor**

Jan. 19—Ladies' night.

Feb. 16—Fundamental Physical and Psychological Aspects of Television, by J. O. Perrine, Am. Tel. & Tel. Co. Demonstrations. Meeting to be held in the auditorium of the Michigan Bell Tel. Co.

**Lehigh Valley**

Jan. 15—Primary Network Distribution Systems, by D. K. Blake, Gen. Elec. Co. Meeting to be held at Packard Lab. Lehigh Univ., Bethlehem, Pa.

Feb. 12—Airplane and Ship-to-Shore Communication. Speaker to be announced. Meeting to be held in Scranton.

**Louisville**

Jan. 22—Practical Application of Light Sensitive Cells, by J. V. Briesky, Westinghouse Elec. & Mfg. Co.

Feb. 19—Lightning—Recent Investigations and Findings, by F. W. Peek, Jr., Genl. Elect. Co., Schenectady, N. Y.

**Lynn**

Jan. 6—Ladies' night.

Jan. 16—Inspection trip to Loose Wiles Biscuit Co.

Jan. 20—Local convention. Subject: Centrifugal Air Compression.

**Pittsburgh**

Jan. 12—Dinner meeting. Speaker: Dr. C.E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Joint meeting with student Branches.

Feb. 9—New Developments in Mercury Arc Rectifiers. Speaker from the Westinghouse Elec. & Mfg. Co.

**Pittsfield**

Jan. 19—Personal Turn of Foreign Power Systems, by Philip Sporn.

Feb. 2—Jungle Gods, by Capt. Carl Von Hoffman.

Feb. 16—Man-Made Islands to Speed Ocean Flying, by E. R. Armstrong.

**Seattle**

Jan. 19—Presentation of papers submitted for annual prize competition. Titles and speakers to be announced.

Feb. — —Communication meeting. Speaker to be provided by the Am. Tel. & Tel. Co. Joint meeting with Inst. of Radio Engrs.

**Vancouver**

Jan. 4—Subject and speaker to be announced.

Feb. 1—Metering, by F. J. Bartholomew, Elec. Pwr. Equipment Co., and L. B. Stacey, Packard Elec. Co.

## Past Section Meetings

**Akron**

Oil Purification, by R. P. Dunmire, vice-pres., The Buckeye Lab., Inc. Dinner meeting. Nov. 10. Att. 52.

**Atlanta**

Spain and America, by M. L. Brittain, pres., Georgia School of Tech. Oct. 12. Att. 80.

Technical Achievements vs. Social Responsibility, by J. E. Thomas, Commonwealth & Southern Corp. Joint meeting with A.S.M.E. Nov. 23. Att. 169.

**Baltimore**

Research, Theory, and Practise, by E. L. Manning, Genl. Elec. Co. Demonstrations. Dinner meeting. Nov. 20. Att. 57.

**Boston**

Adventures in Science, by L. A. Hawkins and E. L. Manning, Genl. Elec. Co. Demonstrations. Joint meeting with engineering societies of Boston. Nov. 12. Att. 3,600.

**Chicago**

Adventures in Science, by L. A. Hawkins, Genl. Elec. Co. Joint meeting with the Western Soc. of Engrs. Nov. 28. Att. 392.

**Cincinnati**

New Conceptions in Physics, by Dr. R. C. Gowdy, dean of the college of engineering and commerce, Univ. of Cincinnati. Illustrated. Considerable discussion. Dinner meeting. Oct. 29. Att. 65.

Power System Stability, by Robert Treat, Genl. Elec. Co. Motion pictures showed short circuit tests on the system of the New England Pwr. Co. Nov. 12. Att. 60.

**Cleveland**

Licensing of Engineers, by Dr. W. B. Kouwenhoven of The Johns Hopkins Univ., (Baltimore) vice-pres. A.I.E.E.; Engineering in Russia, by A. G. McKee, pres., Arthur G. McKee & Co. November 19. Att. 281.

**Connecticut**

Modern and Practical Uses of Illumination, by A. J. Sweet, Westinghouse Lamp Co. Dinner meeting. Nov. 19. Att. 50.

**Dallas**

International Telephone Service, by H.S. Osborne, Am. Tel. & Tel. Co., N.Y Illustrated. Nov. 23. Att. 86.

**Detroit-Ann Arbor**

Power System Stability, by Robert Treat, Genl. Elec. Co. Dinner meeting. Nov. 10. Att. 125.

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Dec. 1. Att. 175.

**Erie**

Effects of Electric Shock, by Dr. W. B. Kouwenhoven, of The Johns Hopkins Univ., (Baltimore) vice-pres. A.I.E.E.; European Travelogue, by J. J. Burgoyne, New York Central Rr. Co. Annual banquet and ladies' night at which James Burke of Burke Elec. Co., acted as toastmaster. Nov. 20. Att. 86.

**Fort Wayne**

The Hysteresis Motor, by S.L. Moore, Genl. Elec. Co.; A New Technique in Cathode Ray Oscillography, by C. M. Summers, Genl. Elec. Co. K. E. Ross, Genl. Elec. Co. demonstrated the cathode ray oscillograph. Nov. 19. Att. 80.

**Houston**

International Telephone Communication, by H. S. Osborne, Am. Tel. & Tel. Co., N. Y. Nov. 27. Att. 68.

**Iowa**

Coordination Between Electric Supply Lines and Communication Lines, by H. H. Carl, Northwestern Bell Tel. Co. Demonstrations. Oct. 29. Att. 39.

**Lehigh Valley**

Recent Developments in Surge-Proof Transformers, by H.V.Putman, Westinghouse Elec. & Mfg. Co. Illustrated. L. A. Phillips, Penn. Pr. & Lt. Co., and O. A. Griesemer, Lehigh Portland Cement Co., received prizes for obtaining the largest numbers of national and local members during the past season. Oct. 16. Att. 99.

**Los Angeles**

The Metropolitan Aqueduct, by F.E. Weymouth; Electrical Problems on the Aqueduct, by J. M. Gaylord. Both speakers are connected with the Metropolitan Water District. Dinner meeting. Nov. 10. Att. 205.

**Louisville**

The Mercury Arc Rectifier in Modern D-C. Railway Service, by E.M. Bill, Genl. Elec. Co. Also inspection trip to see the 1,000-kw. 600-volt automatic rectifier installed at the Highland substation of the Louisville Gas & Elec. Co. Nov. 20. Att. 145.

**Lynn**

The Call of the North, by A. H. Merritt. Illustrated. Nov. 4. Att. 1,200.

Inspection trips made Nov. 7 and 14 to the new building and plant of the Boston Herald-Traveler. Total att. 250.

Low Voltage A-C. Network, by O. L. Riggs, Lynn Gas & Elec. Co.; Low Voltage Metering Methods, by H. F. Crotty, Genl. Elec. Co.; Astronomical Time Switches, by F. W. Hottenroth, Genl. Elec. Co. Slides and working models used to demonstrate important features. Nov. 17. Att. 240.

**Memphis**

N.H. Brown, dean of the college of engineering, Arkansas A. & M. College, related instances from his experiences during the infancy of the electrical industry. Nov. 10. Att. 30.

**Milwaukee**

Modern Methods in Aerial Photographic Mapping, by C. H. Birdseye, pres., Aerotopograph Corp. of America. Joint meeting with the Engineers' Soc. of Milwaukee. Sept. 16. Att. 200.

Some Factors Affecting Noise in the Telephone Circuits Arising in Induction Exposures, by H. R. Huntley, Am. Tel. & Tel. Co., N. Y. Illustrated by lantern slides and a complete miniature hook-up of telephone and transmission lines. Joint meeting with Engineers' Soc. of Milwaukee. Oct. 21. Att. 200.

Continuous, Quick-Freeze Process for the Manufacture of Ice, by Wm. H. Taylor, read by Harry Sloan. Motion pictures and slides. Joint meeting with Engineers' Soc. of Milwaukee. Nov. 18. Att. 175.

**Minnesota**

Modern Trends in Illumination, by O. P. Cleaver, Westinghouse Lamp Co. Dinner meeting. Nov. 19. Att. 55.

**Niagara-Frontier**

Keeping Up with Buffalo's Growth—the Changing Requirements for Telephone Service in a Growing City, by B. K. Boyce, N. Y. Tel. Co. Informal dinner at Hotel Statler preceded the meeting. Nov. 20. Att. 115.

**North Carolina**

Incandescent Lamp Efficiency Life Tests, by D. J. Thurston, student, Univ. of No. Carolina; Practical Relay Applications to Transmission Systems, by O. L. Giersch, Duke Pwr. Co.; High-Speed Protective Relays, by A. R. Van C. Warrington, Genl. Elec. Co. Dinner preceding meeting addressed by L. S. O'Roark of the Bell Tel. Lab., Inc., N. Y., on Experiments in Speech and Music. Those elected to take office Jan. 1, 1932, were announced as follows: J. E. Lear, *chairman*; R. L. Stainback, *secy.-treas.*; E. P. Coles, Raymond Hunt, J. E. S. Thorpe, and J. H. Paget, *members exec. committee*. Nov. 10. Att. 115.

**Oklahoma City**

The Arthur S. Huey Memorial Station, by Otis Howard, Oklahoma Gas & Elec. Co. Inspection trip through the station followed. Oct. 30. Att. 60.

International Telephone Service, by H. S. Osborne, Am. Tel. & Tel. Co., N. Y. Dinner meeting. Nov. 20. Att. 85.

**Philadelphia**

Air Conditioning, by J. F. Gaskill, Phila. Elec. Co. Nov. 9. Att. 185.

**Pittsburgh**

Lightning Protection of Overhead Transmission Systems, by W. W. Lewis, Genl. Elec. Co. Joint meeting with the Engineers' Soc. of Western Pa. Nov. 10. Att. 171.

**Pittsfield**

Electrical Research, by E. L. Manning, Genl. Elec. Co. Demonstrations. Dinner meeting. Nov. 3. Att. 950.

Fused Quartz, by P. K. Devers, Genl. Elec. Co. Illustrated. Dinner meeting. Nov. 17. Att. 250.

**St. Louis**

International Telephone Service, by H. S. Osborne, Am. Tel. & Tel. Co., N. Y. Nov. 18. Att. 78.

**San Antonio**

International Telephone Service, by H. S. Osborne, Am. Tel. & Tel. Co., N. Y. Illustrated. Nov. 24. Att. 68.

**Schenectady**

Annual meeting. Oct. 8. Att. 90.

Construction of the George Washington Bridge, by E. W. Stearns, Port of New York Authority. Illustrated. Joint meeting with A.S.M.E. Oct. 29. Att. 250.

Human Engineering, by Col. C. R. Gow, Warren Brothers Co., and prof. of humanics at M.I.T. Joint meeting with the A.S.M.E. Nov. 19. Att. 260.

The Autogiro, by A. E. Larsen, Autogiro Co. of America. Moving pictures. Joint meeting with the A.S.M.E. Dec. 10. Att. 320.

**Seattle**

The Skagit River Power Development, by J. D. Ross, supt. of lighting, City of Seattle. Illustrated. Dinner meeting. Nov. 17. Att. 85.

**Spokane**

Advantages of the New Cascade Tunnel and Main Line Electrification of the Great Northern Railway, by Glen Walker, Great Northern Co. Film—"Electrified Operation of Trains." Nov. 27. Att. 52.

**Syracuse**

Trends in Improvement of Electric Service, by F. A. Hamilton, Jr., Genl. Elec. Co. Slides and moving pictures. Oct. 26. Att. 163.

**Toledo**

Electrons at Work and at Play, by Phillips Thomas, Westinghouse Elec. & Mfg. Co. Demonstrations. Joint meeting with the Affiliated Tech. Societies of Toledo. Nov. 12. Att. 1,200.

System Operation, by F. H. Dubs, Toledo Edison Co.; Power Transformer Design and Tap Changing Under Load, by L. H. Hill, Allis-Chalmers Co. Considerable discussion. Nov. 20. Att. 80.

**Toronto**

Recent Developments in Oil Circuit Breakers, by G. R. Langley, Canadian Genl. Elec. Co. Moving pictures and slides. Nov. 13. Att. 124.

Circuit Breakers for Branch Circuits, by O. S. Jennings, Westinghouse Elec. & Mfg. Co. Demonstrations. Nov. 27. Att. 100.

**Urbana**

Contribution of the Physical Sciences to Human Welfare, by Prof. C. T. Knipp, Univ. Illinois. Demonstrations. Nov. 17. Att. 58.

**Washington**

Registration of Engineers, by Dr. W. B. Kouwenhoven of the Johns Hopkins Univ. (Baltimore) vice-pres. A.I.E.E. Dinner meeting. Nov. 10. Att. 65.

**Worcester**

Uses of the Thyratron Tube, by R. H. Rogers, Genl. Elec. Co. Nov. 12. Att. 60.

## Past Branch Meetings

**University of Alabama**

Joint meeting A.S.C.E. chapter—motion pictures and talks by students. Nov. 16. Att. 40.

**University of Arizona**

Electronic Music, by T. S. Henderson, student. Oct. 16. Att. 5.

Carrier Waves, by C. A. Ferguson, Am. Tel. & Tel. Co. Dinner meeting. Oct. 23. Att. 14.

Thomas Alva Edison, by H. P. McGovern, student. Illustrated. Oct. 30. Att. 7.

The Electron Tube Voltmeter and Ammeter, and the Phase Shifting Bridge, by P. F. Hawley, student. Nov. 6. Att. 7. Film—"The Single Ridge." Nov. 13. Att. 6.

**University of Arkansas**

Lead Acid Batteries, by H. H. Lewis, student; Storage Battery Application, by Erle Cato, student; Review of the Electrical World, by Luther Hildebrand, student; Resistance, by Eugene Ray, student; The Life and Works of Edison, by L. Wasson, student. Nov. 11. Att. 38.

Magnetism, by E. E. Boreland, student; Illumination of Athletic Fields, by F. L. McDonald, student; Research Work, by J. H. Nelson, student. Dec. 2. Att. 42.

**Armour Institute of Technology**

Transmission of Pictures by Wire, by S. R. Sjoderberg, Am. Tel. & Tel. Co., assisted by E. E. Albin. Illustrated. Nov. 7. Att. 65.

Two-Speed Continuous Automatic System, by E. G. Stecher, Chicago and Northwestern RR. Co. Illustrated. Nov. 21. Att. 35.

Film—"The Electric Ship." Dec. 4. Att. 65.

**University of British Columbia**

The Thury System of D-C. Distribution, by G. G. Henderson, student; The Control of High Frequency Oscillators by Means of Quartz Crystals, by A. C. Tregidga, student. Nov. 16. Att. 9.

**Brooklyn Polytechnic Institute**

The Problems Confronted in the Design of a Commercial Short-Wave Receiver for Operation from A. C. Mains, by L. A. DeRosa, student; The Theory of the Induction Voltage Regulator, by Frank Anderson, student. Dec. 2. Att. 19.

**Bucknell University**

Prof. G. A. Irland, counselor, discussed the aims and activities of the A.I.E.E. and stressed the importance of student enrolment. J. A. Everitt elected secy.-treas. Nov. 4. Att. 14.

**California Institute of Technology**

J. R. Howell, Sterling Motor Co., described the characteristics and construction of sterling motors. Nov. 18. Att. 36.

**University of California**

Construction Features of the Hoover Dam, by W. C. Johnson, Westinghouse Elec. & Mfg. Co. Three students presented papers on the life of Michael Faraday. Nov. 10. Att. 31.

Short Cuts in Complex Numbers, by W. J. McLeod, student. Films—"Big Deeds" and "Power Transformers." Nov. 24. Att. 42.

Election of officers: J. J. Cassidy, *chairman*; H. C. Kruger, *vice-chairman*; S. L. Bettis, *secy.*; C. P. Van Camp, *treas.* Dec. 2. Att. 9.

**Carnegie Institute of Technology**

Switchboards and the Work of the Switchboard Engineer, by A. J. Peterson, Westinghouse Elec. & Mfg. Co. Nov. 13. Att. 36.

**Case School of Applied Science**

Resuscitation from Electric Shock, by G. E. Smith, Ohio Bell Tel. Co. Dinner meeting. Dec. 3. Att. 29.

**Catholic University of America**

H. G. Dorsey, U.S. Coast & Geodetic Survey, showed slides illustrating wiring diagrams of the "fathom meter," used to find the depth of water at desired points. Nov. 12. Att. 39.

**University of Cincinnati**

The Application of Fuses to Electrical Distribution Systems, by Frank Sanford, Union Gas & Elec. Co. Nov. 11. Att. 65.

**Clemson Agricultural College**

Practises that Improve the Operation of Electrical Equipment, by C. P. Walker, student. Illustrated lecture on the Genl. Elec. Co. by V. L. Bethea, student. Nov. 5. Att. 40.

Prof. C. M. Asbill gave a talk on radio. Current events presented by J. L. O. Foster, student Nov. 19. Att. 35.

**Colorado State Agricultural College**

Post Graduate Work and Advanced Degrees, by Prof. H. G. Jordan. Dale Pinkerton elected secy. Nov. 9. Att. 24.

**University of Colorado**

Film—"The Story of Nitrocellulose." Nov. 18. Att. 61.

**Cornell University**

The aims and activities of the A.I.E.E. were outlined by Prof. P. M. Lincoln and Prof. R. F. Chamberlain. Nov. 6. Att. 33.

**University of Denver**

Inspection trip to the Valmont plant of the Pub. Serv. Co. of Colo. Nov. 7. Att. 13.

The Effect of Physical Stresses on Magnetic Materials, by Martin Eisendorfer. Dec. 1. Att. 14.

**University of Detroit**

Set Checkers and Radio Maintenance, by J. C. Hoover, Hoover Lab., Inc. Film—"Wizardy of Wireless." Nov. 12. Att. 60.

**Drexel Institute**

Problems of Modern Physics, by Dr. T. H. Johnson, asst. director, Bartol Research Lab. of Swarthmore College. Nov. 19. Att. 36.

**Duke University**

Debate, in which four students participated: Resolved: That Hydro Power is More Economical for the Generation of Electric Power than Steam Power. Nov. 19. Att. 20.

**University of Florida**

Power Distribution for Rapid Transit Lines and Dynamic Braking, by F. B. Gaines, student. Film—"Making of Mazda Lamps." Nov. 18. Att. 45.

Development of the College of Engineering at the University of Florida, by Howard Rybolt, student. Dec. 3. Att. 100.

**Georgia School of Technology**

Three films: "Thomas A. Edison," "Liquid Air," and "How the General Electric Icing Unit Works." Nov. 10. Att. 55.

**Harvard University**

Some Rocks Ahead, by Prof. Philip Cabot. Nov. 19. Att. 77.

**University of Illinois**

Film—"Dynamic America." Nov. 11. Att. 40.

**University of Iowa**

Multi-Mu and Pentode Tubes, by Wendell Seward, student; Induction Furnace, by Jack Sayer, student; Life and Works of Thomas Edison, by Leonard Sahs, student. Oct. 28. Att. 41.

Some Acoustical Problems of Electrical Engineering, by Harold Petersen, student; Modern Street Lighting Practise, by R. K. Meyer, student. Nov. 4. Att. 39.

Film—"The Single Ridge." Nov. 18. Att. 42.

**Kansas State College**

Talk by Arthur Groesbeck of the United Pwr. & Lt. Corp. Moving pictures. Nov. 5. Att. 54. Afternoon meeting. Program repeated same evening. Att. 33.

The Engineer's Work in a Power Company, by Ivan Buys, United Pwr. & Lt. Corp. Dec. 3. Att. 54. Afternoon meeting. Program repeated same evening. Att. 36.

**University of Kansas**

Several 1-min. talks by students and faculty members. Nov. 19. Att. 20.

**University of Kentucky**

Southern California Power Development, by Prof. E. A. Bureau. Nov. 18. Att. 41.

**Lafayette College**

The Bulls Bridge Hydroelectric Power Development, by Richard Brunn, student. Illustrated. November 20. Att. 14.

**Lehigh University**

Thomas Alva Edison, by Sidney Land, student. Illustrated; Four Months in Europe, by Dean Joseph W. Barker, Columbia Univ. Nov. 19. Att. 85.

**Lewis Institute**

The Routine of a Telephone Call, by L. P. Evans, student; The Handling of a Telegram, by M. H. Dressler, student. Nov. 16. Att. 50.

**University of Louisville**

Sound Equipment, by C. C. Baines, Samson Elec. Co. Demonstrations of sound apparatus. Nov. 13. Att. 26.

**University of Maine**

R. E. Young, chairman, outlined the activities at the district meeting held in Rochester in April, 1931. Prof. W. E. Barrows outlined his experiences at the silver jubilee of the Illuminating Engg. Soc. held at Pittsburgh. Oct. 22. Att. 24.

Thomas Edison's Life and Work, by Raymond Hunter, student; Faraday's Life and Work, by Henry Howes, student. Nov. 12. Att. 16.

**Massachusetts Institute of Technology**

Inspection trip through the plant and laboratories of the Simplex Wire & Cable Co. Nov. 4. Att. 30.

The Generation and Distribution of Electric Power, by E. S. Mansfield, Edison Elec. Illum. Co. of Boston. Film—"More Power to You." Nov. 19. Att. 225.

Inspection trip to the Edgar station of the Edison Elec. Illum. Co. of Boston at South Weymouth. Nov. 23. Att. 25.

**Michigan College of Mining and Technology**

W. D. Stewart, student, gave an illustrated lecture on turbo-generators, Equipment and Operation of Radio Station WHDF at Calumet, Mich., by K. M. Smith, student. Nov. 19. Att. 31.

**Michigan State College**

Experiences in Russia, by Mr. McElroy. Joint meeting with A.S.C.E. and A.S.M.E. Branches. Nov. 12. Att. 23.

A Day in the Weather Bureau, by Prof. Seelye, U.S. Weather Bur. at East Lansing. Dec. 8. Att. 24.

**University of Michigan**

The Placement, Training, and Eventual Work of the Engineering Graduate, by W. A. Furst, Westinghouse Elec. & Mfg. Co. Nov. 24. Att. 102.

**Missouri School of Mines and Metallurgy**

L. K. Johnson, student, outlined his experiences while employed by the Genl. Elec. Co. Nov. 4. Att. 16.

Demonstrations. Nov. 18. Att. 15.

**Montana State College**

General Electric Training, by George Lamb; Radio Transmitter Filter Circuits, by H. L. Casey; Nature's Freak—Ball Lightning, by P. B. McAdam, student; The Way to Prosperity and Progress, by C. E. Grunsky, taken from the Oct. 1931 issue of Electrical Engineering, presented by Wm. H. Scheele, student. Nov. 5. Att. 103.

Montana Section as guests of the Branch witnessed displays and demonstrations presented by students. Refreshments. Nov. 19. Att. 462.

**University of Nebraska**

Inspection trip through the offices of Dr. R. L. Smith; X-ray equipment displayed and uses demonstrated. Nov. 4. Att. 50.

**Newark College of Engineering**

Development of Television, by G. R. Ottinger, N. J. Bell Tel. Co. Illustrated. Nov. 23. Att. 46.

**University of New Hampshire**

Michael Faraday's Rise to Fame, by H. L. Wood, student; Combating Magnetism in Watches, by B. Booth, student; The Physical Analysis of Water Coming from a Paper Mill, by L. A. Barker, student; The Advancement of the Turbo-Generator, by J. L. Currier, student. Oct. 3. Att. 32.

The Development of the Microphone, by O. F. Cushman, student; Electricity in Agriculture in Sweden, by H. T. Dickson, student; Another Cure for the Business Depression, by A. E. Dogan, student. Oct. 17. Att. 25.

G. L. Freese, student, described the new bridge to be constructed between Newington and Durham; Functions and Benefits of the A.I.E.E., by P. A. Rolfe, student. Oct. 24. Att. 29.

Illumination of the Home, by C. M. Glidden, New Hampshire Gas & Elec. Co. Illustrated. Nov. 7. Att. 33.

Some of the Problems in the Distribution Department at Cambridge, Mass., by James Allen, New England Gas & Elec. Co. Nov. 18. Att. 45.

### University of New Mexico

M. A. True, chairman, outlined the aims and activities of the A.I.E.E. Nov. 6. Att. 33.

History and Theory of Electrical Precipitation of Solids from Gases, by S. O. Fish, student. Nov. 17. Att. 18.

### New York University

Relays, by G. M. Heckel, student; Arc Welding, by L. Lindorf, student. Oct. 27. Att. 14.

### University of North Carolina

Calculation of Three-Phase Short-Circuit Currents, by O. L. Giersch, Duke Pwr. Co. Nov. 12. Att. 35.

### University of North Dakota

Michael Faraday, by E. Besken, student; Joseph Henry, by Geo. Anderson, student. Nov. 11. Att. 10.

### University of Notre Dame

The Use of Transformers in Telephony, by Henry Cluver, student; The Manufacture of Sound Equipment, by H. H. Shotwell, Operadio Mfg. Co. John Scanlon, student, presented the bi-monthly engg. digest. Nov. 16. Att. 75.

Neon Signs as Used in Advertising, by E. W. Kenefake, student; Commercial Illumination, by O. P. Cleaver, Westinghouse Elec. & Mfg. Co. John Scanlon, student, presented the engg. digest. Nov. 30. Att. 65.

### Ohio State University

Several students gave talks in commemoration of Michael Faraday. Dinner meeting. Nov. 5. Att. 18.

Some Institute Problems and the Electrical Industry, by Dr. C. E. Skinner, pres. A.I.E.E., and asst. director of engg., Westinghouse Elec. & Mfg. Co. Dinner meeting. Nov. 20. Att. 50.

### Ohio University

Making Electrical Transcriptions, by Prof. D. B. Green. Nov. 11. Att. 44.

Prof. W. H. Cooper gave a talk in which he compared the engg. students with students of other professions. Dinner meeting. Dec. 9. Att. 46.

### Oklahoma A. & M. College

Thomas A. Edison, by E. E. Moore, student. Nov. 9. Att. 24.

### Pennsylvania State College

Four students outlined their experiences during summer employment. Oct. 28. Att. 23.

Why Auto Axles Break, by Dr. E. C. Woodruff. Nov. 18. Att. 90.

### University of Pittsburgh

R. E. Bishop, student, outlined his experiences while doing cooperative work with the Ohio Pwr. Co. Oct. 29. Att. 121.

Life and Work of Thomas Edison, by T. Namlick, student; Report on Academy of Arts and Sciences, by J. V. Heisch, student. Nov. 5. Att. 121.

Copper Oxide Rectifiers, by H. L. Lammy, student. Nov. 12. Att. 122.

Secret Service System, by G. S. Onori, student. Nov. 19. Att. 120.

### Pratt Institute

Historical Development of Modern Physical Theories, by J. E. Thompson. Nov. 5. Att. 74.

Manufacture and Testing of Ward-Leonard Vitrohm Resistors, by H.F.McCord, student. Nov. 19. Att. 31.

Sound Reproduction in Talking Pictures, by O. W. Hancock, student. Dec. 3. Att. 20.

### Princeton University

Thyratron Commutator Motor, by Prof. C. H. Willis. Nov. 23. Att. 12.

Communication Problems of Power Utilities, by L. K. Wyatt, student; Pennsylvania Electrification, by L. Thomas, student; Lightning Arresters, by M. Kine, student. Dec. 9. Att. 6.

### Rensselaer Polytechnic Institute

Some Picturesque Spots in the Development of the Incandescent Lamp, by Samuel Ferguson, Hartford Elect. Lt. Co. Nov. 17. Att. 120.

### Rhode Island State College

Electric Welding, by L. C. Breault and B. Porter, students. Oct. 15. Att. 21.

Lagging of Watthour Meters, by Mr. Mobrey. Nov. 5. Att. 34.

Life of Thomas A. Edison, by L. M. Lang, student. Illustrated. Nov. 12. Att. 17.

Airport Lighting, by Geo. Freeman, student; Radio Communication on Trains, by Edward Long, student. Nov. 19. Att. 15.

### The Rice Institute

Film—"Power." Nov. 18. Att. 21.

General discussion. Dec. 3. Att. 13.

### Rose Polytechnic Institute

Life of Faraday, by Wm. Hineline, student. Nov. 25. Att. 36.

Film—"The Magic Circle." Dec. 7. Att. 101.

### University of Santa Clara

Film—"Modern Methods of Riveting." Joint meeting with A.S.M.E. Branch. Nov. 12. Att. 104.

Report of San Francisco A.S.M.E. and A.S.C.E. Section meetings given respectively by Gale Sullivan and A. Porter, students. Joint meeting with A.S.M.E. and A.S.C.E. Branches. Nov. 19. Att. 95.

### University of South Carolina

Film—"Thomas A. Edison," Nov. 5. Att. 42.

Business meeting. Nov. 12. Att. 11.

Santee River Hydroelectric Project, by L. E. Rankin, student; Application of Fourier's Series to Distorted Current Waves, by W. S. Smith, student; Hydroelectric Project on Broad River, by A. B. Urquhart, student. Nov. 19. Att. 43.

### South Dakota State School of Mines

Industrial Control, by F. H. Doremus, Genl. Elec. Co.; The Modern Trend in Steam Turbine Design, by R. A. Halse, Genl. Elec. Co. Nov. 4. Att. 37.

### University of Southern California

E. R. Stauffacher, So. California Edison Co., Ltd., described relay applications on the Edison system. Oct. 27. Att. 31.

M. W. Edwards, Municipal Lt. and Pwr. Dept., City of Pasadena, spoke on the development and expansion of their power plant and interconnecting systems. Nov. 4. Att. 25.

### Stevens Institute of Technology

Motorless Aviation, by H. W. Braendel, student. Nov. 13. Att. 40.

### University of Utah

Inventions of Thomas A. Edison, by S. Ramo, student; Development of the Incandescent Lamp, by F. C. Derrick, student. Nov. 5. Att. 30.

Salesmanship as Related to Engineering, by Mr. Ferguson, Utah Pwr. & Lt. Co. Nov. 19. Att. 35.

### University of Vermont

Prof. L. P. Dickinson, counselor, gave an illustrated lecture on the life and work of Thomas A. Edison. Oct. 26. Att. 20.

Various Types of A-C. Rectifiers, by Prof. L. P. Dickinson, counselor. Nov. 9. Att. 18.

### Virginia Military Institute

Life of Edison, by W. S. Hayman, student; Modern Electricity, by W. L. Calhoun, student; Life of Steinmetz, by F. B. Epps, student; Lightning Electricity, by N. W.Lingman, student. Nov. 14. Att. 57.

### Virginia Polytechnic Institute

Hardening Metals by Magnetism, by A. de Villesante, student; Power Plant of the Akron, by R. C. Beverly, student; Boulder Dam, by C. Gratz, student. Nov. 11. Att. 50.

Rectification of Alternating Current, by D. E. Williams, student; Virginian Railway Power Plant at Narrows, Va., by C. R. Settle, student. Nov. 19. Att. 47.

### State College of Washington

Dean H. V. Carpenter, vice-pres. A.I.E.E., reviewed activities at the 1931 Pacific Coast convention. Oct. 27. Att. 22.

Life and Works of Thomas A. Edison, by D. H. Olney, student. Nov. 17. Att. 34.

### University of Washington

Captain Crim, U.S. Army Ordnance, described methods of electrical firing control. Illustrated. Nov. 12. Att. 27.

Photoelectric Cells and Their Application to Sound Reproduction, by Floyd Norris, student. Nov. 19. Att. 13.

Rock Island Project on the Columbia River, by L. R. Coffin, Puget Sound Pr. & Lt. Co. Dec. 3. Att. 19.

### West Virginia University

Rural Power Transmission, by L. E. Palmer; Arc Welding, by Wm. P. McCue; Ways of Proving Good Welds, by R. W. Blair; D-C. Controlled Relays, by A. W. Friend; Circuit Breakers in the Home, by J. L. Simpson; Transmission and Distribution of Electric Energy, by J. E.Wallace, all students. Nov. 9. Att. 30.

Modern Practises in the Use of Electric Power, by M. Stewart; The Earth's Electric Charge, by F. D. Brown; Night Photography, by E. P. McCue; Electrical Appliances at the Nemacolin Mine, by V. Montieth; Welded Building Construction, by A. Higgins; all students. Nov. 2. Att. 30.

Thomas A. Edison, by Philip Skaff, student. Illustrated. Film—"The Single Ridge," Nov. 9. Att. 30.

### University of Wisconsin

Thyratron Tubes, by C. V. Bullen, student; Calculation of Magnetic Flux Density, by K. J. Rhodes, student. Nov. 9. Att. 67.

### University of Wyoming

Theoretical Functioning of Gaseous Tubes Used for Illumination, by Albert Buchholz and LeRoy Border, students; Practical Application of Gaseous Tubes Used for Illumination, by H. Soule, Western Pub. Ser. Co. Nov. 17. Att. 25.

## Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Balaguer, Manuel M.,c/o International Tel. & Tel. Co.,67 Broad St.,New York, N. Y.
Cater, C.,Sandal, Church Road, Pinner, Eng.
Chilofsky, Joseph, 958 N. 7th St.,Phila. Pa.
Cordier, N.A., 126 Chatterton Pkwy., White Plains, N. Y.
Farnlof, Charles G.T.,1318 Laketon Rd.,Wilkinsburg, Pa.
Gaylord, R.H.,1814 Virginia Rd.,Los Angeles, Calif.
Goldsman, Jacob L.,64 Priory Rd.,Hampstead, London, Eng.
Kamm, J. Lloyd, 1801 N. Lamar St.,Dallas, Texas.
McCulloch, G.B.,McVie Caterers, Ltd.,Sydney, N.S.W.,Australia.
Melson, Sydney W.,Yeatton Woolrich Rd., Abbey Wood, London, S.E.2, England.
Mountain, C.E.,Burma Elec. Supply Co.,Mandalay, Burma, India.

Parr, J.C., 245-71st St., Bklyn., N.Y.
Pierson, Walter D., 4710 Locust St., Phila, Pa.
Pistorius, L.H., 193 Jeppe St., Johannesburg, South Africa.
Schrock, John E., 3720 Main St., Lawrence Park, Erie, Pa.
Stempfle, Frederich, 8126 E. Vernor Highway, Detroit, Mich.
Tate, William, Apartado No. 41, Pula, Mexico.
Thakkur, K.B., Box 654, Whiting, Ind.
Voronovsky, T.G., 1162 Waverly Place, Schenectady, N.Y.

# Employment Notes

## Of the Engineering Societies Employment Service

### Men Available

GRAD. E. E., 24, single, B.S. in E. E., W.P.I. 1931; 4 yr. experience in construction; one in transmission work. Desires work in any E.E. field. Available at once. Location optional. D-45.

1931 GRAD. E.E. of 5-yr. cooperative school, 23, single. Experience includes machine shop practise, telephone central office trouble shooting, and service with large municipal fire alarm system. Desires position with mfg. concern or pub. utility. Will start at bottom. Middle West preferred, elsewhere satisfactory. C-9825.

DESIGN ENGR., col. grad., 38, married; 9 yr. elec. substation and powerhouse design, with switchboards, wiring diagrams, and all other important items; 5 yr. test engr. pwr. station and research labs. Fluently speaks Spanish, German, and Hungarian. Available immediately. U.S.A. or foreign. C-9128.

FINANCIAL ENGR., Cornell (ME-EE); 12 yr. regulatory commission; 4 with utility holding mgnt. corp., 8 months intensive course bond buying dept. leading insurance company; employed almost 4 yr. thereafter on financial and fact-finding investigations by outstanding cons. engg. organization. Desires opportunity New York City. Salary open. C-2953.

M.I.T. GRAD. E.E., 35, married. 6 yr. industrial and teaching experience in E.E. Several years private research and dev. work on own initiative. Good ability, integrity, and personality. Desires univ. teaching for life work. Mid West or South preferred. C-2826.

E.E., grad. southern univ., married, 34, G.E. Test; 10 yr. in utility engg. and maintenance work, (8 on underground distr. system incl. a-c. low voltage networks); desires position with utility in design or maintenance of distr. system. Location immaterial. C-1191.

GRAD. E.E., 26; 9 yr. consisting of power plant and substation constr. and maintenance as draftsman and engg. asst.; street ry. electrolysis surveys; automatic substation design and supervision of construction and maintenance; industrial elect. work as draftsman and engg. asst. Location immaterial. Available at once. C-5151.

ELECT-MECH. ENGR., 28, married, M.E. deg., thoroughly competent mech. and elect. design and dev. of rotating apparatus. First-class references and record of accomplishments. Available on notice. Location immaterial. D-109.

ELECT. ENGR. B.S. from M.I.T. in 1931. American, 25, single. Desires position with mfg. or pub. utility company. Upbringing in business environments qualifies him for sales work also. Eastern states preferred, any other location considered. Available now. D-110.

GRAD. E.E., 21, single, B.S. in E.E. 1931 high scholastic record. Summer experience pub. utility. Interested in position with industrial concern or pub. utility. Available now. New York preferred but not essential. C-9467.

TECH. GRAD. eastern college, B.S. in E.E., 1927. Good tech. background. Knowledge of vacuum tubes, audio amplifiers, and sound reproducing systems. Elect. pwr. distr. and refrig. Traveled extensively as company engr. and representative. Experienced in managerial, executive, sales capacities. Desires position requiring tech. ability and sales personality. C-8231.

MOTOR CONTROL EQUIPMENT ENGR. 25 yr. experience in motor control design, particularly elect. elevator and misc. control problems and layouts. B.S. in E.E. D-120.

RESEARCH ENGR. member A.I.E.E., A.S.M.E., Am. Statistical Soc.; lately with large utility company; change due to organization curtailment. D-112.

SUPERINTENDENT. 20 yr. in the States in constr. and operation of ry., lt. and pwr. properties; 8 yr. similar work in Latin America. Working knowledge of French, Spanish, Portugese. Successful mgt. sales eastern Cuba for large importers. Prefers Latin countries. B-5729.

GRAD. E.E., 1925; 27, single; 1 yr. G.E. Test. 5 yr. engg. dept. of large lt. and pwr. utility. Constr., inspection, investigations, and tests. Desires constr. or sales engg. work, but would consider anything. Location East. Available at once. D-107.

ELECT., DESIGNING DRAFTSMAN, 37, married. 3 yr. Armour Inst., night school, E.E. 9 yr. design of stm. and hydroelect. sta. High and low voltage, substations and steel tower trans. lines, 1 yr. field engr. on trans. lines, 4 yr. constr. workman, 2 yr. operating and load dispatcher. Available now. Anywhere. C-9986-3660-Chicago.

MECH. AND ELECT. ENGR., 32, single, M.E. and E.E. 4 yr. instructor in machine design at Cornell University. 5 yr. Allis Chalmers stm. turb. design and checking, liberal shop experience. Desires at once responsible work offering future opportunities. Middle West preferred. D-122-3680-Chicago.

GRAD. E.E., 31, single, 8 yr. experience, design, and constr. of trans. lines, voltages up to, and incl. 220-kv., outdoor and indoor high voltage substation and distr. networks. Desires position in engg. or constr. dept. of large utility or holding company. Location immaterial. C-3564.

DESIGN ENGR., Westinghouse Engg. and Design School grad. Pwr. and instr. trans. design experience. Now employed. D-131.

SALESMAN, contact representative or mfr. agent; 37, experienced E.E. representative desires position with high grade company mfg. line of high or low voltage equip. for industrial plants or utilities. B-4067.

1931 E.E. Grad., Georgia Tech., cooperative plan. Single, 24, no obligations; 2½ yr. experience battery work; small turbo-generators; installation of pwr. and control equip. machine shops and oil pumping stations, and winding of fractional hp. motors. 4-yr. course Spanish. Available immediately, anywhere. D-127-3694-Chicago.

ELECT. ENGR. 32, single, B.S. E.E., additional work M.E., Phi Kappa Phi. 8 yr. board experience, powerhouse, substation, trans. line, duct system design; estimates, standards, equip. specifications, operation. Responsible, capable engineer asst. Desires position with mfr. or in plant mgnt. for utilities. Salary secondary to opportunity. D-124.

GRAD. ENGR., 41, with mech., structural and elect. experience. 10 yr. with engg. firms handling design and constr. of power and industrial plants. 2 yr. as plant engr. in large factory. Last 5 yr. with pub. utility on indoor and outdoor substations. Unemployed. A-3027.

ELECT. ENGR. 1924 grad., B.S. E.E., 29, married, 7 yr. experience testing, inspecting, installing various elect. equip. Writing reports. Asst. to mgr. pwr. and lt. utility. Purchasing elect. supplies. Available at once. Detailed information gladly given. Welcomes opportunity in operating-maintenance dept., pub. utility or mfg. concern. C-4981.

1931 E.E. GRAD. 6 yr. experience as an amateur radio operator. Experienced in radio receiving and transmitting apparatus. Desires position with radio or telephone concern. Available at once. D-76.

ELECT. ENGR. 30, married, B.S. E.E. 1924. 7 yr. experience design of synchronous motors, generators, condensers, frequency-changers of all speeds, ratings. Familiar with mech. design of synchronous machines and system stability studies. Desires employment with utility company or cons. engg. firm. Location immaterial. One month's notice. D-147.

ELECT. AND ILLUM. ENGR. member A.I.E.E., I.E.S., 16 yr. practical experience, electrician and mechanic, foreman, supt., etc. 10 yr. est. engg. for architects, etc. Some htg. and vent. experience. All around mechanic and electrician, draftsman. Wants work of some kind anywhere; eastern states preferred. C-8460.

GRAD. E.E., 22, single, B.S. E.E. 1931; two yr. experience in mfr. elect. motors and generators, constr., test, and experimental laboratory. Desires connection for design and constr. of generating plants. Prefers New Jersey, but not essential. D-159.

ELECT. ENGR. single, 26, E.E. '30. 15 months G.E. Test. 5 months experience in G.E. Research Laboratory. Desires position in engg. or test dept. of utility or mfg. company. Available at once. Location New York. D-136.

1931 GRAD. E.E. from leading college in N.Y. State desires position in the elec. industry. Experience main motive, age 25. Several languages. Location U.S.A. or any foreign country. Available immediately. D-164.

SALES ENGR., grad. M.I.T. 1925 B.S. E.E. Design experience Penna. R.R. Co., Westinghouse Test, sales course. Sales experience,

## ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
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31 West 39th St.
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W. V. Brown, Manager

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

**Men Available.**—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

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domestic and export elect. equip.; financial training. Desires sales position or one where combined tech. and commercial knowledge is advantageous. At present in New York City. C-1415.

ELECT. ENGR. 28, with mech. and lab. experience. Wishes work especially in connection with elec. rys. Salary not important if work is within New York area. C-8424.

ELECT. ENGR. 24, graduate Calif. Inst. of Tech. 1931. Special training vacuum tubes and communications, also radio experience. Desires position in communications or allied fields. Will start at bottom. Location immaterial; available at once. D-171.

GENERAL ENGR. Univ. education. Westinghouse apprentice. Wide experience. 4 yr. responsible charge of pwr. and wtr. supply for large industrial corp., operating chain of plants. 7 yr. large engg. and constr. corp. Experienced in mech. design, test and operation of pwr. stations. D-172.

ELECT. ENGR., 28, single. Grad. Georgia Tech. '29, B.S. in E.E. and C.E. Westinghouse test floor, engg. school and design school. 1 yr. experience in turbine generator design, incl. dev. work. Desires position with future. Location immaterial. Available at once. C-9923.

ELECT. ENGR. univ. grad., 36, married. Background of 8 yr. experience elect. test, in field and lab. also in erecting equip. Additional 3½ yr. experience in test and manufacture of radio tubes. Desires position with mfr. or lab. Metropolitan New York preferred. Available now. B-8817.

GRAD. E.E. 25, single. B.S.'29 and M.S.'31 from M.I.T. 1 yr. G.E. Test; 4 summers gen'l maintenance work with telephone company. Available at once. Will go anywhere, to any position for which qualified. Salary secondary. D-175.

1931 GRAD. ENGR., with B.E., single, 23, American, desires position in the elect. industry with opportunity for advancement. Location immaterial. D-174.

1931 E.E. GRAD., 23, single, B.S. in E.E. at M.I.T. Summer experience in electric station of pub. utility company. Desires position with pub. utility, elect. or radio mfg. company, salary secondary. Available at once. D-180.

ELECT. ENGR., Cornell. G.E. shops. 5 yr. each: ry. elect. hydroelect. projects; heavy automotive and tractor design and operation; engg. investigations, reports South America, Orient; quantity production high voltage vacuum devices, photoelectric and neon tubes, plant equipment; director electrophysical lab. Geoelectrical surveys for water, ore; own complete equipment. C-7026.

EXECUTIVE, industrial physicist tech. grad. with diversified research experience and excellent engg. training. Desires position with American organization. Will consider opening as asst. to able engr. or business executive. B-8987.

ENGR. INSPECTOR, tech. grad., 19 yr. experience incl. test. and lab. work, valuation, mfg. prod., inspection and expediting production of elect. and mech. pwr. equip. Familiar with latest dev. in elect. pwr. equip. and transmission material. Past 9 yr. represented pub. utility company inspecting and expediting. Position desired. D-179.

GRAD. E. E., 1929, single, 23. 15 mo. as student engineer on G.E. test. Some test, drafting, and switchboard construction experience before graduation. Interested in position with firm doing cons. or constr. work or with utility or manufacturer. Available at once. Location anywhere in U.S. C-8028.

POWER PLANT MGR., SUPT., desires to make change. Married, 33. 3 yr. E.E. course, broad experience, 2 yr. U.S. Navy, 2 yr. large elect. mfg. company, 5 yr. elect. engr. ins. company. 4 yr. power-plant constr., mgt. Middle West preferred; will consider other. Short notice desired. D-187.

ELECT. ENGR., 24, single, Iowa State College, 1931. Experience limited. Desires work with pub. utility or mfg. concern. Salary second to opportunity. Available now. Anywhere in U.S. C-9827.

GRAD. OF NORTH CAROLINA STATE COLLEGE, class '31, B.S. in E.E., desires connection with illuminating concern or work with photoelectric cells. Salary no consideration. Wishes to learn business from bottom up; staying with it. D-144.

GRAD. E.E., 32, single. 3 yr. Westinghouse Test. 7 yr. supervising power plants, substation, transmission line construction. 8 yr. engg. insp., purchasing, expediting, tracer, res. engr. and writing specifications. Excellent reference. Can handle responsibility. Wants connection with pub. utility, holding company, contractor or mfr. Available immediately. Location immaterial. B-9661.

GRAD. E.E., 22, single, B.S. in E.E., 1931, desires work where 5 yr. practical experience as electrician and radiotrician will be of value. C-9896.

ELECT. ENGR., 23, single, 1931 grad., E.E. from Bklyn. Polytechnic Inst. Desires position with electrical industry with an opportunity for advancement. Salary secondary. New York preferred; not essential. D-188.

ELECT. ENGR. 45, univ. grad., experienced in the various branches of elect. engg. work of pwr. companies incl. work for industrial customers, desires position with pwr. company or mfr. Permanent position desired, but will consider temporary work. B-1923.

GRAD. E.E., 24, cooperative college. Experience, design, manufacture, test, repair of indicating instruments, tube testers, a-c. and d-c. power instruments, special instruments, relays. Familiar with test, laboratory equipment. Good background for research or test. Also experience in production. Type of work secondary. Available at once. U.S., Canada. C-9585.

GRAD. E.E. 34, married, 13 yr. experience U.S.A., Europe, Latin America. Drafting, design, supt. of constr., elect. and mech., power plants, a-c. and d-c. substations, industrial electrifications, etc. Also some experience in design of elect. mach. Fluent Spanish. Will consider new field at reasonable salary. C-8553.

ENGG.-PRODUCTION demand close tie for efficiency. Has designed and regulated production in automatic devices, radio receivers, small motors. Also design field and factory high speed test equip. Familiar phonograph recording, vacuum tubes, lab. supervision, constr. E.E. degree, married, 30, locate New York vicinity. D-181.

RESEARCH, DEV. ENGR., 30, B.S. and E.E. Columbia and Harvard univ. 1 yr shop, 6 yr. test., research, development, patent experience on various electrical, electromechanical devices for domestic, industrial applications; proved and substantial record for original work. Engg. and sales promotion, good correspondent. Executive qualifications. A-1 character, personality. C-930.

TRAFFIC ENGR., grad. E.E., 12 yr. experience, pub. utility, municipal organizations in engineering, vehicular traffic control and fire alarm work. Thoroughly experienced, traffic surveys, planning, specifications, installation, etc. of traffic or fire alarm systems. Now completing traffic system in eastern city. Available immediately. B-9408.

ELECT. ENG., 33, married, B.S. E.E. 1921. 10 yr. automotive maintenance. G.E. Test. 3 yr. designing motors, generators, arc welding equipment. 3 yr. developing, designing automotive drive motors, generators, control. 3 yr. automotive development, maintenance bus, cab company. Interested, electrical, automotive, designing, maintenance. D-95.

GRAD. E.E., 46. 18 yr. experience in the manufacture of elect. wiring devices, incl. designing, development, test., estimating, cost and production work. 4 yr. with Underwriters Laboratories charge of branch office making inspections, tests, examinations and reports. Desires position with mfg. concern, inspection bureau or experimental laboratory. C-8449.

ELECT. ENGR., B.S. in E.E. 1928. 6 yr. operating experience in elect. pwr. plants, both hydro and stm., 4 yr. cost accounting, some test. and sales experience. Wishes position with elect. utility or mfg. concern. Single. Salary open. Location U.S. or foreign. C-7796.

# Membership

## Recommended for Transfer

The board of examiners, at its meeting of November 24, 1931, recommended the following Associates for transfer to the grade of Member. Any objection to these transfers should be filed at once with the national secretary.

### To Grade of Member

Board, Virgil Lee, vice-pres. and genl. supt., Pub. Serv. Co. of Colo., Denver
Brain, Vivian J.F., ch. elec. engr., Dept. of Pub. Wks., Sydney, N.S.W., Australia
Burt, Harvey A., asst. supt., hydro and trans., Pub. Serv. Co. of Colo., Denver, Colo.
Carlson, Victor H., asst. to elec. supt., Chile Exploration Co., Chile, S. A.
Carraway, Thomas W., Grinnell Co., Providence, R.I.
Cave, Jere Shunk, ch. engr., The Venezuela Telephone Co., Venezuela, S. A.
Dring, George S., div. plant supt., Am. Tel. & Tel. Co., Denver, Colo.
Fenkhausen, Rudolph H., supt., pwr. dept., Bethlehem Shipbuilding Corp., San Francisco, Calif.
Field, Russell M., section engr., Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Hardaway, Warren D., supt., hydroelec. prod. and trans., Pub. Serv. Co. of Colorado, Denver
Hudson, Floyd E., asst. planning engr., Bangor Hydroelectric Co., Bangor, Me.
Kreul, Albert H., elec. maintenance and constr., Portland G. E. Co., Portland, Ore.
Nichols, Benjamin H., instructor, elec. engg., Oregon State College, Corvallis
Nolan, Thomas J., system operator, Toledo Edison Co., Toledo, Ohio
Rogers, Clarence E., ch. engr., Pacific Tel. & Tel. Co., Seattle, Wash.
Ryan, Richard M., elec. engr., G. E. Co., Kansas City, Mo.
Shirk, William B., steel mill engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Siniapkin, Nicholas M., elec. engr., State Architect's Office, Albany, N.Y.
Smith, Walter F., Jr., member of tech. staff, Bell Tel. Lab., Inc., New York
Sterne, William C., pres., Arvada Electric Co., Denver, Colo.
Wang, Meng, prof. of E.E., Shansi Univ., China

## Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the secretary before January 31, 1932.

Ackerman, F.L., Portalnd G. E. Co., Salem, Ore.
Allen, G.M., Florida Pwr. Corp., Brooksville
Allen, H.O., United Elec. Lt. Co., Springfield, Mass.
Allen, R.I., J.B. Stetson Univ., DeLand, Fla.
Anderson, L.W., Genl. Elect. Co., Louisville, Ky.
Armstrong, W.M., Stanford Univ. Stanford Univ., Calif.
Ashkenazi, M.A., Phila. Elect. Co., Pa.
Atwater, E., Bell Tel. Labs., N.Y.C.
Aydelott, J.C. (Member) Genl. Elect. Co., Erie, Pa.
Baer, W.K., Underwriters Labs., N.Y.C.
Bange, R.M., N. Y. Edison Co., N.Y.C.
Barrett, J.S., 20 Fair St., Nantucket, Mass.
Barrett, R.E., Jr., Holyoke Wtr. Pwr. Co., Mass.
Bartley, E.A., Allis-Chalmers Mfg. Co., West Allis, Wis.
Bassett, L.R., Int'l. Business Mach. Corp., Rochester, N.Y.
Behrens, H.F., Brooklyn Edison Co., N.Y.
Bell, J. D., Jr., H.&G. Refrig. Co., Columbia, S.C.
Berner, J.A., Northern States Pwr. Co., Minneapolis, Minn.
Biggi, J.F.A., Westn. Union Tel. Co., N.Y.C.
Biskeborn, M.C., Bell Tel. Labs., Inc., N.Y.C.
Black, H.M., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Blackbourn, F.E., Milwaukee Sch. of Engg., Wis.
Bolze, J.N., 2730 Humphrey St., E. Elmhurst, L.I., N.Y.
Bond, D.H., New Orleans Pub. Serv. Inc., La.
Border, G.M., Bell Tel. Labs., N.Y.C.
Borngesser, R.H., Dept. of City Transit, Phila. Pa.

Bost,W.A.,Texaco Prod. Co.,Tulsa,Okla.
Bostick, D. R.,Carolina Pwr. & Lt. Co.,Raleigh, N.C.
Bradley,W.T.,Dept. of City Transit, Phila., Pa.
Branch,G.R.,Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Brenneman,A.G.,Hydro-Elect.Pr.Comm.ofOnt., Hamilton, Ont., Can.
Brieger,E.W.,Univ. of Texas, Austin, Tex.
Brockmeyer,H.,Wis. Telephone Co.,Milwaukee, Wis.
Brouse,H.L.,Rutgers Univ.,New Brunswick,N.J
Bruse,C.B.,Purdue Univ.,W.Lafayette, Ind.
Buchhart,P.W.,Pa. RR. Co., Phila.,Pa.
Burgess, E.H.,N.Y. Central RR., Harmon,N.Y.
Burgess,T.J.,Hydro-Elect. Pr. Comm. of Ont., Hamilton, Ont.,Can.
Byrne, H.E.,Detroit Edison Co., Mich.
Callaghan,J.L.,City of Baton Rouge, La.
Carbray,F.J.,Bell Tel. Co. of Can.,Montreal, Que.,Can.
Cartwright,G.H.,Rollins Col.,Winter Park, Fla.
Cavanagh,G.,North Am. Lt. & Pwr. Co., Chicago, Ill.
Chabot,R.L.,Bell Tel. Co. of Pa.,Pittsburgh, Pa.
Chapin,E.W.,U.S. Dept. of Com.,Baltimore,Md.
Chapman,H.D., Hydro-Elect.Pr.Comm. of Ont., Toronto, Can.
Chatham,A.A.,Case Sch. of Ap. Science, Cleveland, Ohio
Chick,J.E.,(Member) Westinghouse Elec. & Mfg. Co.,Akron,Ohio
Cillie,C.D.,Int'l. G.E. Co.,Schenectady, N.Y.
Clark,N.C.,Univ. of South. Calif.,Los Angeles.
Cline,T.H.,Purdue Univ.,W. Lafayette, Ind.
Connelly,J.S.,N.Y. Telephone Co.,N.Y.C.
Cooper,W.T.,1514 North Shore Ave.,Chicago,Ill
Coryell,W.R.,Washington Univ.,St.Louis, Mo.
Countryman,C.,Coxsackie, N.Y.
Crenshaw,R.F.,Am. Tel. & Tel. Co.,Memphis, Tenn.
Daebler,O.F.,Philadelphia Elect. Co., Pa.
Datshkovsky,E.,1809 So. Ridgeway Ave.,Chicago, Ill.
Davis,E.R.,Duke Power Co.,Charlotte, N.C.
Davis,P.A.,Genl. Elec. Co.,Bridgeport, Conn.
Dean,J.E.,Detroit Edison Co., Mich.
Dempsey,E.J.,Linde Air Prod. Co.,N.Y.C.
Diehl,S.C.,Lehigh Univ.,Bethlehem, Pa.
DiIorio,F.,Jr.,217 Canal St.,Staten Island,N.Y.
DiJulio,F.,Lewis Inst. of Tech.,Chicago, Ill.
Douglass,G.W.(Member)N.J. Bell Tel. Co., Newark, N.J.
DuMont,P.J.,Genl.Elect.Co.,Schenectady, N.Y.
Dunlap,R.S.,Westinghouse Elec. & Mfg. Co., E. Pittsburgh,Pa.
Dyleswski,T.J.,Univ. of Cincinnati, Ohio
Earnhart,G.W. (Member) U.S.Dept. of Com., Denver, Colo.
Eastman,A.A.,G. E. Lt. Inst.,Cleveland, Ohio
Fenn,F.H.,Louisiana State Univ.,Baton Rouge, La.
Filman,P.T.,Pa. Pwr. & Lt. Co.,Williamsport
Fletcher,W.B.,Am. Tel. & Tel. Co., Providence, R.I.
Fletemeyer, L.H.,Jr., Roessler & Hasslacher Chemical Co., Niagara Falls, N.Y.
Forbes,A.D.,Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Frye,C.C.,Genl. Elec. Co.,Erie, Pa.
Gahagan,J.E.,United Elect. Lt.& Pr.Co.,N.Y.C.
Gardner,G.S.,(Member) Asso. Tel. & Tel. Co., Chicago, Ill.
Gentilini,C.,Westinghouse Elec. & Mfg. Co., Wilkinsburg, Pa.
Ghamat,S.B., Sch. of Engg. of Milwaukee, Wis.
Goldberg,Y.,Des Moines Elec. Lt. Co.; Iowa Pr. & Lt. Co.,Ia.
Graham,H.E.,1230 E. 69th St.,Chicago, Ill.
Green,F.A.,Twin Coach Corp.,Kent, Ohio
Griffith,D.P.,718 Fifth St.,Catasauqua, Pa.
Gurley,G.H.,Univ. of Kans.,Lawrence, Kans.
Halbach,E.A.,Marquette Univ.,Milwaukee,Wis.
Hale,J.A.,Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Hall,J.R.,Allis-Chalmers Co.,W. Allis, Wis.
Hanley,C.M.,N. Y. Telephone Co.,N.Y.C.
Hannon,M.W.,Hoosier Pub. Utility Co.,Osgood, Ind.
Harrower,G.A.,325 Simpson St.,New Westminster, B.C., Can.
Hastad,O.J.,Bell Tel. Lab.,N.Y.C.
Hattox,J.G.,Worcester Poly. Inst.,Worcester, Mass.
Haydock,J.G.,Jr.,Philadelphia Elec. Co.,Pa.
Hazell,W.,Jr.,Diehl Mfg.Co.,Elizabethport,N.J.
Heckert,R.B.,Standolind Pipe Line Co.,Tulsa, Okla.
Heil,H.R.,Brooklyn Edison Co.,N.Y.
Henry,M.,(Member)Col. of the City of N. Y., N.Y.C.
HensleyM.S.,Am. Tel. & Tel. Co., Kansas City, Mo.
Hepler,K.G.,Carnegie Inst. of Tech., Pittsburgh, Pa.
Himebrook,F.S.,Ohio State Univ.,Columbus
Hoffman,E.C.,Naval Gun Factory, Washington, D.C.
Howard,W.S.,Luther Hill High School, May, Okla.
Huang,P.,Mass. Inst. of Tech.,Cambridge,Mass.
Hubbard,D.C.,Virginia Pub. Serv. Co.,Clifton Forge
Inslerman,H.E., Micamold Radio Corp.,Bklyn, N.Y.
Jackson,E.S.,Jr.,Consumers Pwr. Co.,Grand Rapids, Mich.
Janer,A.N.,530 W. 144th St.,New York, N.Y.
Jensen,W.H.,Genl. Elec. Co.,Schenectady, N.Y.
Jeryan,P.E.,RCA Victor Co.,Phila.,Pa.
Jones,A.A.,Anaconda Wire & Cable Co.,Hastings-on-Hudson, N.Y.
Jordan,S.R.,Univ. of Ill.,Urbana, Ill.
Kantayya,A.G.,Rensselaer Poly.Inst.,Troy,N.Y.
Keyuha,J.,West Virginia Univ.,Morgantown
Keaney,D.E.,Worcester Poly. Inst.,Mass.
Kelley,D.P.,Bell Tel. Lab.,N.Y.C.
Kennedy,E.D.,Rutgers Univ., New Brunswick, N.J.
Kennedy,F.H.,Jr.,Rensselaer Poly. Inst., Troy, N.Y.
Kinney,F.M.,R. R. No. 2, Clyde, Ohio
Knack,W.L.,Dunlop Tire & Rubber Co.,Buffalo, N.Y.
Kresser,J.V.,Westinghouse Elec. & Mfg. Co.,E. Pittsburgh, Pa.
Kunins,M.K.,U.S. Dept. of Com., Buffalo, N.Y
LaBarge,K.F.,Fisher Body Corp.,Detroit,Mich.
Langaunet,J.C.,W. Penn Pwr. Co.,Elizabeth,Pa.
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| ☐ 32-19 | D. W. Roper | Studies in Lightning Protection on 4,000-Volt Circuits—III |
| ☐ 32-20 | H. A. Dambly, H. N. Ekvall, and H. S. Phelps | Distribution System Lightning Studies by Philadelphia Electric Co. |
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| British Columbia, Univ. of | Vancouver, B. C | 10 | D. S. Smith | H. M. Van Allen | E. G. Cullwick |
| Brooklyn, Poly. Inst. of | Brooklyn, N. Y | 3 | F. Anderson | I. Andreasen | H. B. Hanstein |
| Bucknell Univ | Lewisburg, Pa | 2 | Walter E. Hall | J. A. Everitt | G. A. Irland |
| Calif. Inst. of Tech | Pasadena, Calif | 8 | P. B. Lyons | R. W. St. Clair | R. W. Sorensen |
| Calif., Univ. of | Berkeley, Calif | 8 | John J. Cassidy | Sherroll L. Bettis | L. E. Reukema |
| Carnegie Inst. of Tech | Pittsburgh, Pa | 2 | W. B. Wigton | F. A. Lennberg | George Porter |
| Case Sch. of Ap. Science | Cleveland, Ohio | 2 | W. J. Lattin | K. R. Spangenberg | H. B. Dates |
| Catholic Univ. of America | Washington, D. C | 2 | Ralph Brady | R. F. Bourne | T. J. MacKavanagh |
| Cincinnati, Univ. of | Cincinnati, Ohio | 2 | W. Kock | C. J. C. Schmidt | W. C. Osterbrock |
| Clarkson College of Tech | Potsdam, N. Y | 1 | C. O. McNairn | J. H. O'Rourke | A. R. Powers |
| Clemson Agri. College | Clemson College, S. C | 4 | H. S. Montgomery | C. A. Farish | S. R. Rhodes |
| Colorado State Agri. College | Ft. Collins, Colo | 6 | Leroy Sweet | D. Pinkerton | F. L. Poole |

## Student Branches of the Institute—Continued

| Name | Location | District | Chairman | Secretary | Counselor (Member of Faculty) |
|---|---|---|---|---|---|
| Colorado, Univ. of | Boulder, Colo | 6 | F. W. Cooper | W. C. Spear | W. C. DuVall |
| Cooper Union | New York, N. Y | 3 | A. B. Mundel | E. Sarver | A. J. B. Fairburn |
| Cornell University | Ithaca, N. Y | 1 | R. A. Smith | W. S. Bachman | E. M. Strong |
| Denver, Univ. of | Denver, Colo | 6 | L. C. Trussler | Irwin Olcott | R. E. Nyswander |
| Detroit, Univ. of | Detroit, Mich | 5 | B. Sharkey | J. Schenk | H. O. Warner |
| Drexel Inst | Philadelphia, Pa | 2 | G. Koster | G. Mitz | E. O. Lange |
| Duke Univ | Durham, N. C | 4 | S. G. Flack | J. A. Womack | W. J. Seeley |
| Florida, Univ. of | Gainesville, Fla | 4 | R. E. Walker | L. P. Barnett | Joseph Weil |
| Georgia School of Tech | Atlanta, Ga | 4 | J. H. Harrison | J. S. Gantt | T. W. Fitzgerald |
| Harvard Univ | Cambridge, Mass | 1 | E. A. Walker | C. N. Mason | C. L. Dawes |
| Idaho, Univ. of | Moscow, Idaho | 9 | Glenn E. Gage | H. R. McBirney | R. H. Hull |
| Illinois, Univ. of | Urbana, Ill | 5 | B. Burgoon | D. L. Pettit | C. E. Skroder |
| Iowa State College | Ames, Iowa | 5 | Edwin K. Rohr | Alfred F. Zissler | F. E. Johnson |
| Iowa, State Univ. of | Iowa City, Iowa | 5 | David Marchant | Albert Behnke | E. B. Kurtz |
| Kansas State College | Manhattan, Kansas | 7 | G. E. Cain | D. E. West | R. G. Kloeffler |
| Kansas, Univ. of | Lawrence, Kansas | 7 | Edward Fisher | Jack Brous | D. C. Jackson, Jr. |
| Kentucky, Univ. of | Lexington, Ky | 4 | W. A. Hunter | H. F. Day | W. F. Freeman |
| Lafayette College | Easton, Pa | 2 | Henry H. Jones | G. D. Hegeman, Jr | Lawrence Conover |
| Lehigh Univ | Bethlehem, Pa | 2 | L. F. Underwood | C. W. Banks | N. S. Hibshman |
| Lewis Inst | Chicago, Ill | 5 | L. P. Evans | H. May | F. A. Rogers |
| Louisiana State Univ | Baton Rouge, La | 4 | P. W. Stokeley | E. R. Wilkinson | M. B. Voorhies |
| Louisville, Univ. of | Louisville, Ky | 4 | P. A. Frank | H. K. Friedman | S. T. Fife |
| Maine, Univ. of | Orono, Maine | 1 | R. E. Young | R. J. Tibbetts | W. E. Barrows |
| Marquette Univ | Milwaukee, Wis | 5 | Ellsworth Ziehm | Donald Boehmer | Edward Kane |
| Massachusetts Inst. of Tech | Cambridge, Mass | 1 | J. C. Gibson | T. R. Smith | W. H. Timbie |
| Michigan Col. of Mining and Tech | Houghton, Mich | 5 | C. A. Doremire | H. H. Kramer | G. W. Swenson |
| Michigan State College | East Lansing, Mich | 5 | Edwin W. Moore | Webster Bowler | W. A. Murray |
| Michigan, Univ. of | Ann Arbor, Mich | 5 | Gary Muffly | John M. Lyon | S. S. Attwood |
| Milwaukee, School of Eng. of | Milwaukee, Wis | 5 | A. Oklund | R. Stephenson | V. M. Murray |
| Minnesota, Univ. of | Minneapolis, Minn | 5 | M. G. Swanson | S. McDermott | J. H. Kuhlmann |
| Mississippi Agri. & Mech. Col | A. & M. College, Miss | 4 | J. M. Caldwell | J. F. Barksdale | L. L. Patterson |
| Missouri School of Mines & Met | Rolla, Mo | 7 | W. O. Woods | H. W. Short | I. H. Lovett |
| Missouri, Univ. of | Columbia, Mo | 7 | J. E. Shepherd | L. E. Bates, Jr | M. P. Weinbach |
| Montana State College | Bozeman, Mont | 9 | Homer Lambdin | W. C. Funk | J. A. Thaler |
| Nebraska, Univ. of | Lincoln, Neb | 6 | P. Ehrenhard | Wm. A. Ely | F. W. Norris |
| Nevada, Univ. of | Reno, Nevada | 8 | Donald Knapp | O. E. Reil | S. G. Palmer |
| Newark College of Eng | Newark, N. J | 3 | E. Clsta | A. E. Day | J. C. Peet |
| New Hampshire, Univ. of | Durham, N. H | 1 | P. A. Rolfe | R. H. Williams | L. W. Hitchcock |
| New Mexico, Univ. of | Albuquerque, New Mexico | 7 | M. Austin True | S. O. Fish | F. M. Denton |
| New York, Col. of the City of | New York, N. Y | 3 | A. Rosenberg | I. E. Lawlor | Harry Baum |
| New York Univ | Univ. Heights, New York, N. Y | 3 | L. E. Dinnar | G. M. Heckel | J. L. Arnold |
| North Carolina State College | Raleigh, N. C | 4 | G. E. Ritchie | L. C. Hubbard | R. S. Fouraker |
| North Carolina, Univ. of | Chapel Hill, N. C | 4 | D. J. Thurston, Jr | Sam Barham | J. E. Lear |
| North Dakota Agri. College | Fargo, N. D | 6 | Fred Payne | Ralph Simenson | H. S. Rush |
| North Dakota, Univ. of | Grand Forks, N. D | 6 | B. J. Shields | Mark Scarff | H. F. Rice |
| Northeastern Univ | Boston, 17, Mass | 1 | K. N. Packard | S. A. Standing | W. L. Smith |
| Notre Dame, Univ. of | Notre Dame, Ind | 5 | Hugh Ball | F. A. Consolati | J. A. Caparo |
| Ohio Northern Univ | Ada, Ohio | 2 | O. R. Jacobs | W. Gideon | I. S. Campbell |
| Ohio State Univ | Columbus, Ohio | 2 | C. L. Lucal | G. W. Moyer | F. C. Caldwell |
| Ohio Univ | Athens, Ohio | 2 | George Wyckoff | C. C. Colombo | A. A. Atkinson |
| Oklahoma Agri. & Mech. College | Stillwater, Okla | 7 | J. W. Hutchins | C. V. Benson | A. Naeter |
| Oklahoma, Univ. of | Norman, Okla | 7 | C. C. Ludwick | J. Strossberger | F. G. Tappan |
| Oregon State College | Corvallis, Ore | 9 | Dale Hansen | George Howie | F. O. McMillan |
| Pennsylvania State College | State College, Pa | 2 | J. N. Seller | J. W. Hostetter | L. A. Doggett |
| Pennsylvania, Univ. of | Philadelphia, Pa | 2 | C. N. Maxfield | H. D. Sarkis | C. D. Fawcett |
| Pittsburgh, Univ. of | Pittsburgh, Pa | 2 | R. A. Hartley | J. W. Stirling, Jr | H. E. Dyche |
| Pratt Inst | Brooklyn, N. Y | 3 | Wm. H. Sutton | R. L. Bishop | C. C. Carr |
| Princeton Univ | Princeton, N. J | 2 | F. Siedler | J. H. Burnett | Malcolm MacLaren |
| Purdue Univ | Lafayette, Ind | 5 | P. O. Peterson | E. M. Sharer | A. N. Topping |
| Rensselaer Poly. Inst | Troy, N. Y | 1 | J. J. Lewis | H. A. Schlieder | F. M. Sebast |
| Rhode Island State College | Kingston, R. I | 1 | L. C. Breault | L. E. Crandall | Wm. Anderson |
| Rice Inst | Houston, Texas | 7 | M. E. Kattmann | E. A. Turner, Jr | J. S. Waters |
| Rose Poly. Inst | Terre Haute, Ind | 5 | J. Montgomery | Paul Froeb | C. C. Knipmeyer |
| Rutgers Univ | New Brunswick, N. J | 3 | F. Fisher | L. V. Banta | F. H. Pumphrey |
| Santa Clara, Univ. of | Santa Clara, Calif | 8 | L. W. Thorpe | T. Eberhard | E. F. Peterson |
| South Carolina, Univ. of | Columbia, S. C | 4 | L. E. Rankin | L. W. Dickinson | T. F. Ball |
| South Dakota State Sch. of Mines | Rapid City, S. D | 6 | A. M. Bjerke | C. C. Stephens | J. O. Kammerman |
| South Dakota, Univ. of | Vermillion, S. D | 6 | Myron Cole | C. Bauman | B. B. Brackett |
| Southern California, Univ. of | Los Angeles, Calif | 8 | M. C. Marshall | Louis Bayha | W. G. Angermann |
| Southern Methodist Univ | Dallas, Texas | 7 | J. V. Melton | R. L. Allen | H. F. Huffman |
| Stanford Univ | Stanford University, Calif | 8 | M. R. Jones, Jr | R. H. Born | W. Bryan Duncan |
| Stevens Inst. of Tech | Hoboken, N. J | 3 | F. L. Fuller | R. A. Chadburn | F. C. Stockwell |
| Swarthmore College | Swarthmore, Pa | 2 | L. Fussell, Jr | R. H. Lamey | Lewis Fussell |
| Syracuse Univ | Syracuse, N. Y | 1 | M. A. Collins | M. E. Hogan, Jr | C. W. Henderson |
| Tennessee, Univ. of | Knoxville, Tenn | 4 | H. M. Patterson | C. T. Nunley | J. G. Tarboux |
| Texas Agri. & Mech. College | College Station, Texas | 7 | R. L. Suggs | C. H. Samuels | H. C. Dillingham |
| Texas Tech. College | Lubbock, Texas | 7 | J. M. Dyer | C. T. Hatchett | W. J. Miller |
| Texas, Univ. of | Austin, Texas | 7 | T. E. Cole | D. Sussin | J. A. Correll |
| Utah, Univ. of | Salt Lake City, Utah | 9 | R. C. Hansen | W. S. Nishiyama | J. H. Hamilton |
| Vermont, Univ. of | Burlington, Vt | 1 | D. E. Child | R. A. Hyde | L. P. Dickinson |
| Virginia Military Inst | Lexington, Va | 4 | J. C. Shell | E. R. Trapnell | S. W. Anderson |
| Virginia Poly. Inst | Blacksburg, Va | 4 | R. E. McDaniel | P. H. Cross | Claudius Lee |

## Student Branches of the Institute—Continued

| Name | Location | District | Chairman | Secretary | Counselor (Member of Faculty) |
|---|---|---|---|---|---|
| Virginia, Univ. of | University, Va. | 4 | T. J. Peterson | T. A LoCascio | W. S. Rodman |
| Washington, State Col. of | Pullman, Wash | 9 | D. H. Olney | G. C. O'Brien | O. E. Osburn |
| Washington Univ | St. Louis, Mo | 7 | Don A. Fischer | E. A. Wolff | W. L. Upson |
| Washington, Univ. of | Seattle, Wash | 9 | Allen S. Koch | Donald A. Date | G. L. Hoard |
| West Virginia Univ | Morgantown, W. Va | 2 | A. W. Friend | Philip Skaff | A. H. Forman |
| Wisconsin, Univ. of | Madison, Wis | 5 | T. N. Racheff | O. F. Vea | C. M. Jansky |
| Worcester, Poly. Inst | Worcester, Mass | 1 | R. G. Driscoll | Wm. A. Ardito | C. D. Knight |
| Wyoming, Univ. of | Laramie, Wyo | 6 | Neil Sanders | Roy Perkins | G. H. Sechrist |
| Yale Univ | New Haven, Conn | 1 | L. B. Hansen | F. M. Wolff | W. B. Hall |
| Total 109 | | | | | |

## Affiliated Student Society

Brown Engineering Society..........Brown Univ., Providence R. I.

# Engineering Literature

## New Books

### In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during November are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

KINEMATICS OF MACHINERY. By C. D. Albert and F. S. Rogers. N. Y., John Wiley & Sons, 1931. 527 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, $4.50.——This textbook is based upon the course given to engineering students at Cornell University but contains advanced material, in addition to that included in most courses, upon velocity and acceleration vector diagrams, cams, and spur gears. The treatment is concise, yet thorough, and many problems are included.

PRINCIPLES OF DIRECT-CURRENT MACHINES. By A. S. Langsdorf. 4th ed., N. Y. & London, McGraw-Hill Book Co., 1931. 586 pp., illus., diagrs., charts, tables, 8 x 6 in., cloth, $4.50.——This well-known text aims to supply a reasonably complete treatment of the fundamental principles that underly the design and operation of all types of d-c. machinery. This edition has been extensively rewritten, and new material has been added to bring it abreast of modern practise.

RADIO FREQUENCY ELECTRICAL MEASUREMENTS. By Hugh A. Brown. N. Y. & London, McGraw-Hill Book Co., 1931. 386 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, $4.00.——The fundamentals of the standard methods are presented together with some of the recent advances in this field. The theory and principles are explained, the necessary steps in the laboratory procedure or manipulation are described, and the precision attainable, the precautions, and the general merits of the methods are discussed. The book is intended for students of radio communication and electrical measurements and also is designed to serve as a manual for the radio engineer.

THEORIE DER THERMISCHEN MESSGERATE DER ELEKTROTECHNIK, Grundlagen zu ihrer Berechnung. By J. Fischer. Stuttgart, Ferdinand Enke Verlag, 1931. 147 pp., diagrs., charts, tables, 10 x 7 in., paper, 13 RM.——Presents in systematic form the theoretical principles underlying hot-wire instruments, thermocouples, bolometers, and similar instruments, and summarizes the results of research upon the question of heat transfer. This knowledge is then used to discuss the theory of the various types of instruments. The book supplies the designer with the fundamental data that he needs.

PRINCIPLES OF ELECTRICAL ENGINEERING. By G. C. Blalock. N. Y., McGraw-Hill Book Co., 1931. 498 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, $4.00.——A concise course in the fundamentals, with frequent references to practical applications. The text is intended primarily for students of civil, chemical, or mechanical engineering but may also be used by students of electrical engineering as an introduction to the subject.

RADIO RECEIVING TUBES. By J. A. Moyer and J. F. Wostrel. 2nd ed. N. Y., McGraw-Hill Book Co., 1931. 323 pp., illus., diagrs., charts, tables, 8 x 5 in., cloth, $2.50.——The essential principles underlying the operation of vacuum tubes are explained in simple, non-technical fashion in this book, which will meet the needs of the average student of radio communication. The construction, action, reactivation and testing of vacuum tubes are described, and their uses as detectors, amplifiers and oscillation generators explained. A chapter is devoted to specifications, and another to the applications of vacuum tubes to other industrial uses than radio transmission and reception.

SCIENCE IN ACTION. By E. R. Weidlein and W. A. Hamor. N. Y., McGraw-Hill Book Co., 1931. 310 pp., illus., tables, 9 x 6 in., cloth, $3.00.——This book gives a readable account of the methods by which scientific investigation has been applied to the problems of manufacturing, and of what has been accomplished by it. The history of industrial research is outlined, and some major achievements in promoting human welfare, in creating new industries, in preventing waste, and in improving social conditions are set forth. Suggestions for the organization of research work and the selection of workers are given.

A.S.T.M. TENTATIVE STANDARDS 1931. Philadelphia, Am. Soc. for Testing Mtl. 1008 p., 9x6 in., cloth, $8; paper, $7.——Tentative specifications, methods of test, and recommended practises which had been proposed to the association, but had not been formally adopted in September, 1931. 180 standards are given, 42 of which appear for the first time.

CONVERSION EQUIVALENTS IN INTERNATIONAL TRADE. By S. Naft. Philadelphia, Comm'l Museum, 1931. 357 p., 9x6 in., cloth, $5.——An unusually comprehensive collection of weights and measures. Factors and tables for converting the units of all countries are given in more than usual detail; tabulated alphabetically and geographically, as well as by systems. Attention is paid to compound conversions and to special measures used in engineering, commerce and various industries.

DIESEL REFERENCE GUIDE. By J. Rosbloom. Jersey City, N. J., Industrial Institute, Inc., 1931. 292 p., 10x8 in., cloth, $10.——Intended as a reference work for diesel engine owners, manufacturers and operators; brings together in convenient form such practical information as: theory and construction of the engines, their installation and management, accessories, fuels, repairing, descriptions of locomotive, airplane, and automobile engines. Diesel engine installations in America are listed.

ECONOMIC CONTROL OF QUALITY OF MANUFACTURED PRODUCT. By W. A. Shewhart. N. Y., D. Van Nostrand Co., 1931. 501 p., 9x6 in., cloth, $6.50.——An important work upon the use of statistical methods in the study of the problem of controlling the quality of manufactured articles. Using as an illustration the experience of the Bell Telephone Laboratories in developing the most efficient ways of applying these methods to the problems that arise in manufacturing, he explains clearly the mathematical and statistical principles that are involved, and shows how they are applied to actual problems.

### ENGINEERING SOCIETIES LIBRARY

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MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

# Selected Items From Current Literature

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 2,000 technical periodicals are given in the following columns. All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page, or make translations of foreign articles at cost.

### CABLES

**Rubber Insulated.** New Control Cables Have Improved Characteristics, H.M.Friend. *Power*, v 74, Nov 10, '31, p 666-9. Developments made in insulated wire and cable based on recent discoveries by rubber chemists and physicists and experimental research work of cable manufacturers in applying these discoveries; results of tests on rubber insulated cable.

**Telephone.** Placing of Aerial Cables by Suspension, R.Blain. *Telephone Engr.*, v 35, Oct '31, p 25-7. Importance of placing messenger at proper tension in aerial cable construction is explained; construction and use of tension indicator.

**Underground—Manholes.** Steel Forms for Concrete Manholes Show Economies, A.J.Batchelor. *Elec. World*, v 98, Oct 31, '31, p 777. $27.10 saving per job on labor alone is realized by Toledo Edison Co. through use of steel forms for building concrete underground system manholes; in the year since these forms were adopted company has used them eight times.

### CIRCUIT BREAKERS

**Oil.** The Impulse High-speed Circuit Breaker, W.K.Rankin. *Gen. Elec. Rev.*, v 34, Oct '31, p 553-8. Initially developed for 25-cycle railway use; serviceable also for 60-cycle distribution; design based on new theory of current interruption; arc-quenching oil-blast produced mechanically; description of operation of mechanism and electrical performance.

### CLOCKS

**Electric.** Electric Clocks, S.F.Philpott. *Elec. Rev.*, v 109, Oct 23, '31, p 626-7. Consideration of relative advantages of various types available.

### CRANES

**Electric.** New Type Crane and Hoist, G.A. Caldwell. *Elec. World*, v 98, Oct 17, '31, p 692-5. Motor-generator set used as exciter for main a-c. crane or hoist motor to give dynamic control in lowering operations; principles used and description of application; practise illustrated on Brooklyn installation; speed-torque curves.

### DUST PRECIPITATION

**Electric.** Selecting Equipment for Electrostatic Precipitation, R.H.Kaufmann. *Chem. and Met. Eng.*, v 38, Oct '31, p 570-2. Development of applications of Cottrell process; precipitation treater for recovery of sulphuric-acid mist; how high-voltage d-c. supply for treater operation can be obtained; removal of tar and residues from gases in precipitation treater.

### DYNAMOMETER

**Electric.** Electric Dynamometers for Production Testing, F.W.Highfield. *Machy.*, v 39, Oct 1, '31, p 12-7. Operating principles and appl. with particular regard to testing of internal combustion engines. Before Instn. Production Engrs.

### ELECTRIC DRIVE

Individual Drives Simplify Roll-Table Operation, W.B.Snyder. *Elec. World*, v 98, Oct. 10, '31, p 650-2. Conveyor tables with motor on each roll have had their greatest development and application in steel industry; but reduced maintenance, ease of control, and quiet operation should fit it into any industry where materials of suitable length are handled in processes of manufacture.

**Industrial Plants.** Electric Drive in Factories, W.P.Conly. *Elec. Rev.*, v 109, Oct 9, '31, p 527-8. Comparison with crude-oil engine; some data regarding consumption of electricity per hp. installed in different trades; results of analysis for various types of plants given in tables.

**Pumps.** Control of Synchronous Motor Pump Drives, R.C.Allen. *Maintenance Eng.*, v 89, Sept '31, p 462-5. Factors to be considered in appl. of synchronous motor to pump drive; control equipment; advantages of increased efficiency, and better power factor weighed against complexity of operation.

### ELECTRIC MACHINERY

**Testing.** Losses in D-C Machines from No-Load Tests, R.G.Isaacs. *Instn. Elec. Engrs.—Jl.*, v 69, Oct '31, p 1303-8. Determination of rotational losses of dynamos and motors that occur on load, by means of no-load test which allows for increase of iron losses due to load; theory of test and method of carrying it out; typical results show probable accuracy of method.

### ELECTRIC MEASURING

**Instruments.** Electroscope Capacity Balance, W.O.Bayliss. *Australasian Elec Times*, v 10, Sept 28, '31, p 368-70. Apparatus developed by E.B.Brown exhibited at Melbourne Univ. Eng. School enables determination to be carried out very much more rapidly than, and quite as accurately as, usual methods.

### ELECTROMAGNETS

Design and Construction of an Electromagnet for Investigation, E.J.Shaw. *Rev. Sci. Instruments*, v 2, Oct '31, p 611-7. Familiar du Bois type of magnet was not particularly suited for number of investigations of magnetic properties of atoms and molecules performed in laboratory of Univ. of Ill.; special type of electromagnet designed shows four outstanding features over type mentioned.

### ELEVATORS

**Control.** Pliotron Tubes Level Elevators in McGraw-Hill Building. *Power*, v 74, Nov 3, '31, p 632-5. In new 33-story McGraw-Hill Building are 9 passenger and 5 freight elevators equipped with Pliotron leveling devices; elementary connection diagram of Pliotron elevator control system.

**Door Operation.** How Hoistway Door Operation Affects Elevator Service, H.B.Cook. *Power*, v 74, Oct '31, p 608-9. Method for determining force necessary for opening and closing different types of elevator hoistway doors and what effect increasing time of operation has on door mechanism.

### ENGINEERS

**Employment.** How Many Engineers Are Now Unemployed? H.M.Friend. *Power*, v 74, Oct 27, '31, p 600-4. Analysis of survey based on Engg. Societies Empl. Service and various state and government agencies; registrations and placements per 1,000 members of 1927 to 1931.

### FEEDWATER

**Treatment.** Solubility of Calcium Salts in Boiler Water, F.G.Straub. *A.S.M.E.—Advance Paper* for mtg. Nov 30-Dec 4, '31, 6 p. Purpose of investigation to determine behavior at elevated temperatures of various chemical compounds found in boiler waters.

### FURNACES

**Arc.** Twenty Year Advance in Electric Arc Furnaces, W.E.Moore. *Heat Treating and Forging*, v 17, Oct '31, p 982-7. Paper before Electrochem. Soc. previously indexed from their preprint, no 60-11 for mtg. Sept. 2-5, 1931.

**Industrial.** Industrial Gas and Electric Furnaces, E.Gossow. *Eng. Progress*, v 12, Oct '31, p 217-22. Operating characteristics and classification of industrial furnaces; furnace atmosphere; gas furnace, fuel gases, burners; examples of large industrial installations.

**Melting.** The Manufacture of Acid Electric Steel and Cast Iron, H.H.Walther. *Iron and Steel Engr.*, v 8, Oct '31, p 415-22. Practical features involved in successful economical operation of electric furnaces of 3-ton per hr. capacity, direct arc, 3-phase; electric furnace costs covering 4-week period.

### GATES

**Hydraulic Ellipsoid.** Lightness and Low Costs Obtained by New Penstock Gate Design, A.J.Ackerman. *Eng. News-Rec.*, v 107, Oct 15, '31, p 600-4. Design and fabrication of ellipsoid, nearly all welded, emergency gate, 16 ft.in diam., for pressure tunnel at Calderwood dam in Tennessee; maximum head of 260 ft. was assumed; special tests of restrained plates.

### HYDROELECTRIC

**Power Irrigation.** Hydro Power Provides Revenue for Irrigation Works, H.A.Brown. *Power*, v 74, Nov 10, '31, p 663-5. By combining power development with irrigation dams possible to pay project's construction costs from power sales.

### INSULATING MATERIALS

**Specifications.** Methods of Test Relating to Electrical Insulating Materials. *A.S.T.M.—Report Committee* D-9, '31, 212 p. Compilation of standards and tentative standards, together with annual report of committee.

### LAMPS

**Arc.** Construction and Operation of Capillary Mercury Arcs, R.H.Crist. *Optical Soc. America—Jl.*, v 21, Oct '31, p 690-7. Nature of problem and experimental development; nature of deposit; character of emission; curves.

**Glow.** A Cold-Cathode 110-Volt Gaseous Illuminant. *Electronics*, v 3, Oct '31, p 140-1. Two forms of Spanner Germer-Doring gaseous lamp adapted for operation in standard lamp socket for 110 volts a-c. or d-c.

### LIGHTING

**Airplane.** Lights for Airplanes, R.W.Cost. *Elec. Jl.*, v 28, Oct '31, p 573-5. Equipment and its installation; notes on incandescent lamps; navigation; instrument board lights; cabin lights; landing lights; lighting circuits.

**Airport.** The Detroit City Airport Anticipates Night Flying, H.K.Flint. *Elec. Jl.*, v 28, Oct '31, p 566-7. More than 50 floodlights, each producing beam intensity of about 10,000,000 candle-power, furnish illumination for night movements of airplanes at Detroit City Airport.

**Fog.** Transmission of Light Through Fog, F.C.Breckenridge. *Aircraft Eng.*, v 3, Oct '31, p 261-4. Attempt to correlate results of fog-chamber investigations by C.L.Utterback, S.H. Anderson, and H.G.Houghton, and with natural fog by E.Farrer, E.P.T.Tyndall, F.Benford, L.P.Granath and E.O.Hulburt; particle sizes; formation of haze particles. Before Int. Illum. Congress.

**Houses.** Your Lights at Home, M.A.Sheppard. *Elec. Jl.*, v 28, Oct '31, p 553-6. Rich market lies before electrical industry; best attack is probably encouraging those in industry to have their own homes adequately lighted; lights must be integral part of home furnishings rather than afterthought.

**Street.** Modern Street Lighting Practise, L.A.S.Woods. *Elec. Jl.*, v 28, Oct '31, p 557-9. Modern city plans its street lighting from investigation of requirements for each locality; outstanding examples of such comprehensive street-lighting plans are cities of Milwaukee and St. Louis. Before Int. Commission of Illum.

**Street Cutouts.** Series Street Lamp Has Inbuilt Cutout. *Elec. Jl.*, v 28, Oct '31, p 570. Novel idea of using one of best conductors, copper, for insulator is basis of new inbuilt cutout for series lamps; copper particles are covered with insulating film, which breaks down at lamp failure, allowing copper to fuse and reestablish circuit.

### LOUD SPEAKERS

**Diaphragms.** Behaviour of Conical Diaphragms used in Acoustic Apparatus for Reproduction of Speech and Music, N.W.McLachlan and G.A.V.Sowter. *Lond., Edinburgh and Dublin Philosophical Mag. and Jl. Science*, v 12, Oct '31, p 771-815. Conical Diaphragms with free edge, with reinforced edge and with rubber surround; comparison of three preceding cases; modes of diaphragm corresponding to upper frequency resonances; influence of coil mass, etc.

**Horns.** Indoor Applications of Air-Column Horns, C.J.Brown. *Projection Eng.*, v 3, Oct '31, p 15-6. Type of horn to be used under given conditions is described and illustrated.

### MAGNETISM

Temperature Variation of Intrinsic Magnetization and Associated Properties of Ferromagnetics, E.C.Stoner. *Lond., Edinburgh and Dublin Philosophical Mag. and Jl. Science*, v 12, Oct. '31, p 737-63. Relation of intrinsic magnetization to other properties of ferromagnetics is briefly discussed, and evidence for regarding ferromagnetism at ordinary temperatures as due to interchange interaction of electron spins is summarized. Bibliography.

New Theory of Magnetic Storms—I—Initial Phase, S.Chapman and V.C.A.Ferraro. *Terrestrial Magnetism and Atmospheric Electricity*, v 36, June '31, p 77-97 and Sept p 171-86. Motion of infinite plane-slab stream, cylindrical stream and neutral ionized system of any form in uniform magnetic field; internal steady motion of neutral ionized stream in non-uniform magnetic field; phenomena accompanying advance of solar ionized stream into earth's field.

### MANHOLES

**Standardization.** Simplification and Standardization of Manhole Frames and Covers, L.B. Fish. *ASA Bul.*, Sept '31, p 26-8. Progress reports of sectional committee of ASA Telephone Group and A.S. of C.E.; types and sizes reduced; simplification of materials.

### MANOMETERS

**Vacuum Tube.** Measuring One Trillionth of an Atmosphere, E. K. Jaycox, *Bell Lab. Rec.*, v 10, Oct '31, p 34-8. In making studies of phenomena requiring high degree of vacuum, it is important that physicists have knowledge of degree of pressure within apparatus; ionization manometer for accomplishing this was invented by O.E.Buckley in 1916; ionization manometer for this purpose of new design has been recently developed by H.W.Weinhart and author.

### MICROPHONES

**Moving Coil.** A Moving Coil Microphone for High Quality Sound Reproduction, W.C.Jones and L.W.Giles. *Projection Eng.*, v 3, Oct '31, p 10-2. Microphone described is more efficient than conventional form of condenser microphone and its transmission characteristics are unaffected by changes in temperature, humidity and barometric pressure.

### MOTORS

**Commutator.** Alternating-current Commutator Motors. *Engineering*, v 132, Oct 30, '31, p 559-60. 90-hp., 220-volt, 3-phase machine, built by Holmes for abnormal range of 12.5 to 1, has speed range of from 375 to 30 r.p.m., with constant torque of 1,200 ft.-lb.

**Design.** Design of Electric Motors for Intermittent Service, C.Schiebeler. *Engineering*, v 132, Oct 30, '31, p 566-8. Study of conditions in motor when operating on short-interval intermittent service.

**Induction.** Induction Motors for Frequent Reversing, R.F.Emerson. *Power*, v 74, Nov 3, '31, p 637-8. Practical discussion of effects of motor-reversing operations; curves showing number of reversals possible with 50 deg. cent. rise when using general-purpose squirrel-cage motor and motor with high-resistance rotor.

**Railroad.** Field Shunting and Modern Motor Design, L.B.Hewitt. *Elec. Ry., Bus and Tram Jl.*, v 64, Mar 13, '31, p 141-3. If interest in this direction can be stimulated one may have hope that manufacturers will produce suitable motors designed for far greater range of field control than any at present on market; economies to be obtained together with savings in weight, cost of resistances, and control equipment would be more than adequate compensation.

**Single-Phase.** Capacitor Single-Phase Motors, L.T.Campey. *Maintenance Eng.*, v 89, Sept '31, p 427-31. Review of theory and design, and general statement of applications, discussing advantages and limitations; motor operation curves and control.

**Squirrel Cage.** Some Features of the Polyphase Squirrel-Cage Induction Motor, F.Miller. *Gen. Elec. Rev.*, v 34, Oct '31, p 548-52. Mechanical construction; stator windings; final drying and insulating; electrical relationships; characteristics of motor with respect to rotor design; characteristic curves as samples of rotor punching are given.

## NETWORKS

New System of Distribution. *Elec. News*, v 40, Nov 1, '31, p 35-7. Proposed type of general purpose system for moderately loaded areas that utilizes single conductor, shielded aerial cables, supported by messenger forming common neutral of 4,600/8,000Y volt circuit; details of system.

**Design.** A Proposed Type of General Purpose Distribution System for Moderately Loaded Areas, G.H.Underhill. *N.E.L.A.—Bul.*, v 18, Oct '31, p 669-77 and 693. Proposed system is advanced areas; it utilizing single conductor, shielded aerial cables, supported by messenger which forms common neutral of 4,600/8,000Y volt circuit. Paper won first award in James H. McGraw prize contest for 1931.

**Frequency Operation.** Changing a System Frequency—I, E.Smart. *Elec. Lt. and Pwr.*, v 9, Nov '31, p 26-8. Empire District Electric Co. of Joplin, Mo., completed 25-cycle to 60-cycle conversion project at cost of $2,000,000; project included replacement of original turbines and 25-cycle generators in Company's main hydroelectric plant on White River, with 60-cycle equipment having total capacity of 20,000 kw.; conversion of 66-kv. circuit and connections thereto to 60-cycle service.

## OSCILLOGRAPHS

**Cathode-Ray—Measurements.** Phase Measurements with the Cathode Ray Oscillograph, L.A.Wood. *Rev. Sci. Instruments*, v 2, Oct '31, p 644-8. Theoretical mathematical analysis, pertaining to suitability for oscillograph for this type of measurements.

## PHOTOELECTRIC CELLS

New Applications of Photo-Cells for Control of Handling Equipment, R.F.Yates. *Matls. Handling and Distribution*, v 6, Sept '31, p 45-6. Features of application of photo-cells for automatically controlling conveyoring equipment in filling of ore and grain bins.

Engineering Development of Photovoltaic Cells, C.G.Fink and D.K.Alpern. *Am. Electrochem. Soc.—Trans.*, v 58, '30, p 275-98. New photovoltaic cell, designed for industrial purposes, is described and some operating data and characteristic curves are presented, as introduction to general treatment of subject; cell contains lead anode and copper-oxide cathode.

**Applications.** Electronic Control of Machinery, R.F.Yates. *Iron Age*, v 128, Nov 5, '31, p 1170-2. Photoelectric tubes are designed for various specific operating conditions not admitting use of mechanical counters; thyratrons controlling comparatively large current without mechanical relays.

## POTENTIOMETER RECORDERS

New Brown Potentiometer Recorder, T.R. Harrison. *Rev. Sci. Instruments*, v 2, Oct '31, p 618-25. Brown potentiometer recorder is illustrated and described in some detail; is suited to use as self-balancing wheatstone bridge, for resistance thermometry, and for many other uses.

## POWER INDUSTRY

**Accounting.** Accounting Fundamentals Applied to Purchased and Generated Power, J.W. Romig. *Power*, v 74, Oct 27, '31, p 605-7. Separating fixed charges for economic comparisons; features of mixed-pressure unit; uses of variable and fixed costs.

**Rate Making.** How to Handle a Rate Case, C.B.Cooke,Jr. *N.E.L.A.—Bul.*, v 18, Oct '31, p 657-9. Cost-to-company is more practical and reliable index for permissible rates to large customers than value of service to them which is usually greater than can be obtained in rate.

## PUBLIC ADDRESS SYSTEMS

Design and Assembly of Outdoor Public-Address Systems, G.S.Mitchell. *Projection Eng.*, v 3, July '31, p 14-6. Instructive details of unit assembly and placement for outdoor sound transmission.

High Power for the Public-Address System, C.H.W.Nason. *Projection Eng.*, v 3, Oct '31, p 14. Availability of type 556 mercury-vapor rectifier simplifies construction of outdoor sound system; installation for theater, auditorium or outdoor use, wherever high quality channel of power involved is desired, is shown schematically.

An Audio-Radio Distribution and Control Circuit, R.P.Glover. *Electronics*, v 3, Oct '31, p 155. In some instances it would be desirable to retain feature of selection and control over radio programs at individual receiving points and at same time afford advantages of centralized distribution of voice and records; schematic diagram of such installation is shown.

## RADIO

**Antennas.** Development of Directive Transmitting Antennas by R.C.A. Communications, Inc., P.S.Carter, C.W.Hansell and N.E.Lindenblad. *I.R.E.—Proc.*, v 19, Oct '31, p 1773-1842. Various types of directive antennas are theoretically analyzed and their performances under practical conditions studied; effects of seasonal variations, heights above ground and polarization are considered; radiation properties of simple wires and radiation patterns of various combinations of wires are described in detail.

**Antennas—Short Wave.** Developments in Short-Wave Directive Antennas, E.Bruce. *Bell Syst. Tech. Jl.*, v 10, Oct '31, p 656-84. Previously indexed from *I.R.E.—Proc.*, Aug. 1931.

**Circuits.** Series Equivalent of a Resistance Paralleling a Tuned Circuit, C.H.W.Nason *Radio Eng.*, v 11, Oct '31, p 28. Simple mathematical analysis of determining effect of resistance and detector circuit.

**Engineers.** The Spokesman for the Radio Engineer, S.O.Hooper. *I.R.E.—Proc.*, v 19, Oct '31, p 1843-8. Radio today is compromise between engineers, department store managers, politicians, theater owners, and lawyers; had engineers proceeded properly in beginning they would have first reached accord among themselves as to what set-up should be; problem of getting Congress and executive branch to provide needed laws and regulations would have been very easy.

**Interference.** Radio Interference. *Elec. Mfg.*, v 8, July '31, p 31-2. Factors to consider when selecting motors; table shows part electric motors played in causing radio interference in 16 cities of less than 15,000 population.

**Interference.** High-Frequency Atmospheric Noise, R.K.Potter. *I.R.E.—Proc.*, v 19, Oct '31, p 1731-65. Method which has been employed in measurement of high frequency atmospheric noise is described; using this method measurements of noise over range from 5 to 20 megocycles made in different parts of U.S.A. and at different times of year, show distinct diurnal change in intensity similar to that for long-range high-frequency signal transmission.

**Inverters.** D-C. Inverter for Radio Receivers, W.R.G.Baker and J.I.Cornell. *Electronics*, v 3, Oct '31, p 152-4. Device for changing d-c. into a-c.; supplies a-c. from d-c. mains at required voltage and frequency and may be mounted in cabinet with receiver; development has been made possible through use of thyratron

**Receiving Apparatus, Short-Wave.** Factors in the Selection of the Proper Radio Power Transformer, J.A.Comstock. *Radio Eng.*, v 11, Oct '31, p 17-9. Transformer should meet tolerances set forth by radio engineer, and in most cases these are in neighborhood of plus and minus 3 per cent on filament windings and plus and minus 5 per cent on high voltage windings and be capable of withstanding dielectric tests specified by Underwriters' Laboratories, and application.

**Telegraph.** Application of Printing Telegraph to Long-Wave Radio Circuits, A.Bailey and T.A.McCann. *Bell Syst. Tech. Jl.*, v 10, Oct '31, p 601-15. Arrangements which have been used for start-stop printing telegraph operation over transatlantic long-wave radio channel.

**Waves, Long—Measurement.** Long-Wave Radio Receiving Measurements at the Bureau of Standards in 1930, L.W.Austin. *I.R.E.—Proc.*, v 19, Oct '31, p 1766-72. Tables of monthly average field intensities of various long-wave stations, and corresponding atmospheric disturbances measured in Washington in 1930.

**Waves, Ultra-Short.** The Attenuation of Ultra-Short Radio Waves Due to the Resistance of the Earth, R.L.Smith-Rose, and J.S.McPetrie *Phys. Soc.—Proc.*, v 43, Sept 1, '31, p 592-612. Investigation of attenuation of radio waves, of wavelengths between 5 and 10 meters, when transmitted directly along earth's surface; transmitters employed, one being fixed installation used with input power supply of order of 500 watts, other transportable set operated with input supply of about 50 watts obtained from batteries, are described.

## RAILROADS

**Controllers.** New Cam Type Controller. *AEG Progress*, v 7, Sept-Oct '31, p 190-3. Features and characteristics of new AEG type, *i. e.*, contacts, contact fingers, arc-extinguishing devices, contact pressure and action, contact battens, cam drum, notched wheel, reversing and braking drums; design of housing, connections and mode of operation; 60,000 km. service within interval of two main inspections without overhaul of contacts cited.

**Economics.** Economics of Electric Railway Operation, J.R.Ong. *Elec. Traction*, v 27, Oct '31, p 498-9, see also *Elec. Ry. Jl.*, Oct '31, p. 570-1. Faster schedules of paramount importance; new equipment increases riding; reducing operating expenses; savings in bus operation; savings in reducing costs of accident. Before A.E.R.A.

**Power Supply.** Power Generation and Distribution Have Undergone Many Changes, C.R. Harte. *Elec. Ry. Jl.*, v 75, Sept 15, '31, p 542-5. Historical review of power plant design and electric power distribution for street railroads; details of specific installations.

**Regenerative Control.** Tramway Regeneration, G.H.Fletcher. *Elec. Ry., Bus and Tram Jl.*, v 65, Sept 18, '31, p 132-45. Manchester Tramway System and Tramways Department of Glasgow decided made trial with Parisian system; in both cases series-parallel scheme was selected; results obtained from Manchester experiment; brief description of car and its equipment. Before Manchester Mun. Tramways and Transport Assn.

**Signals and Signaling.** Chicago, St. Paul, Minneapolis and Omaha Eliminates Nearly 20,000 Train Stops Annually. *Ry. Signaling*, v 24, Oct '31, p 337-41. Grade crossing with Chicago, St. Paul, Minneapolis and Omaha, gauntlet drawbridge, and junction switches controlled by table interlocking machine; mechanical gate protection solves light-traffic crossing problem.

**Signals and Signaling—Interlocking.** C.B. and Q. Installs Electric Interlocking, W.F. Zane. *Ry. Signaling*, v 24, Oct '31, p 331-4. Plant first of six large signaling units in rearrangements of Galesburg, Ill., terminal facilities; schematic diagram showing general layout; track-and-signal plan of controlled territory; outside equipment; cable distribution.

Power Interlocking Eliminates Delays. *Ry. Signaling*, v 24, Oct '31, p 342-4. Reconstruction program involves installation of two electro-pneumatic plants on Norfolk and Western at Portsmouth, Ohio; track layout; a-c. operation and control in both plants.

Chicago and Illinois Midland Installs Electric Interlocking. *Ry. Signaling*, v 24, Oct '31, p 335-6, and 341. Crossing with Wabash protected by modern plant; highway crossing protection special features; track-and-signal plan of plant at Springfield, Ill.; interlocking machine; signals and switch machines; special crossing signs.

Remote Control for Interlocking Saves $6000 Annually. *Ry. Signaling*, v 24, Oct '31, p 345-6. 30-lever plant, including highway-crossing protection now handled by all-relay control with 7-lever centralized-type machine in station 1.2 mi. away; control machine; layout plan of remotely controlled plant; control circuit; yard indicator.

**Signals and Signaling—Remote Control.** The Operation of Long-Distance Points by Hand-Generated Power—I. *Ry. Engr.*, v 52, Oct '31, p 370-4. Outline of systems whereby long-distance low voltage point mechanism operates without batteries; arrangement of lines and signals, circuits for long-distance point operation Great Southern Railways, Ireland; past and present arrangement of lines and signals at Collooney.

**Tracks.** Advances in Electric Railway Track Construction Standards. *Can. Ry. and Mar. World*, Oct '31, p 653-4. Diagrams illustrating design and constructional features.

**Train Control—Equipment.** How to Use a Train Control Output Meter. *Ry. Elec. Engr.*, v 22, Oct '31, p 268-9. Periodic checking of loop and track phase circuits provides means for determining condition of train control equipment and lessens possibility of failure.

## REACTORS

**Control.** Direct-Current Controlled Reactor, E.C.Wentz. *Elec. Jl.*, v 28, Oct '31, p 561-3. Long known as 3-legged reactor, apparatus is really analogous to 3-element amplifier tube and can be used as regenerative amplifier; it may also be used as relay, or as variable reactor; characteristic curves, practical uses and hook-ups.

## RECTIFIERS

Series-parallel Type Static Converters—II, C.A.Sabbah. *Gen. Elec. Rev.*, v 34, Oct '31, p 580-9. Polyphase series-parallel or series polycyclic static converter is discussed; definition and description; calculation of circuit; voltage relations; interphase transformer voltage; general graphical method and circle diagram or polar coordinates; numerical examples of calculation of 3-phase circuit by analytical method.

**Transformers.** Method for Eliminating Pulsations in the Terminal Voltage of Mercury Arc

Rectifiers, K.Ohsumi. *Inst. Elec. Engrs. Japan —Jl.*, v 51, July '31, p 380-5; see also English Abstract, on p 61-3. For extinguishing all alternating components from output voltage of rectifiers, author devised single-phase 3-winding transformer which is described in detail.

### REGULATORS

**Induction.** The Application of the Induction Voltage Regulator, W.E.M.Ayers. *Instn. Elec. Engrs.—Jl.*, v 69, Oct '31, p 1208-18 and (discussion) 1218. General application of induction regulators to feeder systems and distribution networks; problem of fully automatic control; application of regulator in system considered from its practical and economic aspects; financial aspect; twin polyphase induction regulators; special applications and connections.

### RELAYS

**Testing.** Theory and Application of Relay Systems—Relay Testing and Maintenance—I, R.H.Robinson and I.T.Monseth. *Elec. Jl.*, v 28, Oct '31, p 581-4. Investigation of new relays; initial tests; testing induction-type relays; directional tests.

### SUBSTATIONS

**Work Designs.** Tapping 110-Kv. Trunk Line to Serve Small Community. *Elec. World*, v 98, Oct 31, '31, p 776-7. Sevierville, 110/13.8-kv. substation of Tenn. Pub. Serv. Co., represents another effort on part of power companies to provide small community with good electrical service from high-voltage trunk line without unduly hazarding trunk-line service.

### SYMBOLS

**International Electrotechnical Commission.** International Symbols—III; Graphical Symbols for Weak-Current Systems. *I.E.C.—Pub.* no. 42, '31. Symbols for practical purposes representing object in very reduced and simple form and making it possible to draw any diagram in minimum time while giving it all desired clearness and convenient size. (In French and English.)

**Standardization.** The A.I. & S.E.E. Suggestions to the Electrical Manufacturers in Connection with Standardized Symbols for Control Apparatus. *Iron and Steel Engr.*, v 8, Oct '31, p 438-9 and (discussion) 439-45. Tab. of suggestions.

### TELEPHONE

**Exchanges—Airships.** Aerial P.B.X. on World's Largest Airship, A.Parlett, Jr. *Telephony*, v 101, Oct 31, '31, p 31-2. Description of telephone installation on U.S.S. Akron, world's largest airship recently built for U.S. Navy, comprised of specially constructed switchboard and 17 telephones.

**Receivers—Moving Coil.** Moving-Coil Telephone Receivers and Microphones, E.C. Wente and A.L.Thuras. *Bell Syst. Tech. Jl.*, v 10, Oct '31, p 565-76. Moving coil head receiver and microphone designed particularly for high quality transmission; instruments have substantially uniform response from 40-10,000 c.p.s.

**Relays.** Characteristics of Strowger Relays, K.W.Graybill. *Telephone Engr.*, v 35, Oct '31, p 30-1. Characteristics of various special types of relays in curves are given and explained.

**Systems—Interconnection.** Interconnection of Telephone Systems—Graded Multiples, R.I.Wilkinson. *Bell Syst. Tech. Jl.*, v 10, Oct '31, p 531-64. General problem of subscriber interconnection; economic and service factors in selection of trunking systems; characteristic manner in which telephone calls fall upon ordinary straight trunk groups; theoretical analysis of graded multiples from which are constructed curves for common probabilities of loss; comparison of theory and observation.

### TELEVISION

Technical Problems in Connection with Television, C.O.Browne. *Instn. Elec. Engrs.—Jl.*, v 69, Oct '31, p 1232-8. Present day television is confronted with two main problems, that of transmitting signals which correspond to picture elements necessarily embracing large frequency band; second, that of providing sufficient illumination on receiver screen to enable audience to view received image simultaneously.

**Apparatus.** A Television Projector for Screen Pictures. *Projection Eng.*, v 3, July '31, p 13. Projector type televisor, designed by DeForest engineers, which throws television pictures received on screen so that they may be seen by small theater audience; extreme flexibility for television flying spot, is obtained.

**Apparatus, Superheterodyne.** Television Reception with the Superheterodyne, R.W. Tanner. *Radio Eng.*, v 11, Oct '31, p 23-5. Engineering details of design of superheterodyne receiver suitable for television.

**Fidelity Charts.** Measurement of Fidelity in Television Systems, A.F.Murray. *Electronics*, v 3, Oct '31, p 137-8. Reproduction of charts devised in R.C.A. Victor Research Laboratory for measuring fidelity and for comparison of shades.

### THERMOCOUPLES

New Uses for the Thermocouple. *Projection Eng.*, v 3, Oct '31, p 13 and 15. New type of thermocouple potentiometer of General Electric Co. for accurate temperature measurements; principle overcomes need for standard cell, which requires frequent balancing to make certain that potentiometer current has not varied.

### TRANSFORMERS

Recent Progress in Large Transformers, R.M. Charley. *Instn. Elec. Engrs.—Jl.*, v 69, Oct '31, p 1189-1207. General description of progress made in recent years and examples illustrating present stage of art; notes on problem of transport; comparison of 3-phase units with banks of single-phase units; shell-type vs. core-type transformers; core construction; cooling; "Intertaire" transformers; Buchholz protective device; interturn insulation; non-resonanting transformers, etc.

**Connection.** Calculation of Line-to-Line Ratios and Phase Angles of a Combination of Three Single-Phase Voltage Transformers Star-Connected on a Three-Phase System, The Star Point being Earthed, A.O.Crawley. *Instn. Elec. Engrs.—Jl.*, v 69, Oct '31, p 1293-4. Development of algebraic expressions for calculation of ratio and phase-angle errors from measured values.

**Silica Gel Breathers.** A Silica Gel Transformer Breather. *Engineer*, v 152, Oct 16, '31, p 418-9. Particulars of breather for transformers, designed to replace those employing calcium chloride; breather can be made for all capacities and can also be applied to joint boxes and oil transport and storage tanks.

### TRANSMISSION LINES

**Calculation.** Symmetrical Components—IX, C.F.Wagner and R.D.Evans. *Elec. Jl.*, v 28, Oct '31, p 586-90. Discussion of phase sequence constants of transmission lines with ground wires; positive and negative sequence impedance; zero-sequence impedance; practical calculation of zero-sequence impedance; electrical characteristics of steel ground wires; copper-clad steel cables.

**Failures.** Interruptions to Lines Concentrated at Sunrise—Why? E.E.George and W.R. Brownlie. *Elec. World*, v 98, Oct 10, '31, p 658-61. Idea of relative importance of lightning and other causes may be had from record of 110 kv. and 154 kv. outages on Tenn. Elec. Pwr. Co.'s transmission system; 70 per cent of non-lightning outages fall in sunrise band; switching operations shifted away from sunrise period.

**Rural—Costs.** Rural Lines for $500 per Mile, M.T.Crawford. *Elec. World*, v 98, Oct 17, '31, p 690-1. Northwest Elec. Lt. and Pwr. Assn., surveyed practise of all member companies and prepared data on types of construction indicating present general practise; cost of special type of construction of Portland Gen. Elec. Co., adding 15 per cent overhead and reasonable amount of secondary circuit, transformers and meters will not much exceed $500 per mile.

### VACUUM TUBES

**Industrial Application.** Electron tube in Machine Design, R.F.Yates. *Machy.* (*N.Y.*), v 38, Oct '31, p 95-6. How vacuum tube, photoelectric cell, and grid-glow tube are being used by machine designers for grading, measuring and counting.

### WATER HEATING

New Possibilities in Off-Peak Water Heating, *Elec. West*, v 67, Oct 1, '31, p 179-81. After study of some months' duration involving analysis of experience with high-voltage water heaters on meter rate and low-wattage heaters on flat rate, and experiments with various types of heaters, tanks and insulation, Puget Sound Pr. & Lt. Co., Seattle, has established new water heating rate offering low priced energy on off-peak hours for storage-type water heaters.

### WELDING

**Arc.** Developments in Arc Welding as Applied to Oil Industry, J.C.Lincoln. *Oil Weekly*, v 63, Oct 16, '31, p 18-24. Application of shielded arc process to welding of pipe lines, oil tanks, vaporizer tubes and other fields and refinery equipment. Before Am. Petr. Inst.

Shielded Arc and the New Code, G.Raymond. *Welding Engr.*, v 16, Sept '31, p 42-4. Qualities of weld metal which are called for by revised A.S.M.E. boiler code; corrosion resistance of shielded arc weld demonstrated by deep etching test; tensile tests of shielded arc welds through which holes have been drilled; bend tests demonstrate ductility and toughness.

**Bronze.** Improved Product by the Use of Bronze Welding, H.F.Reinhard. *Am. Welding Soc.—Jl.*, v 10, Oct '31, p 5-8. Bronze welding as applied to light gage galvanized sheet steel and iron in fabrication of house lighting and cooking type acetylene generator; bronze welded seams 315 per cent stronger than soldered double-lock seams.

**Locomotive Boilers.** Welding Practise in Northern Pacific Boiler Shops. *Boiler Maker*, v 31, Oct '31, p 274-7. Details of welding equipment and practise.

**Locomotive Fireboxes.** Welding in the Locomotive Boiler, J.M.Vossler. *Welding*, v 2, Oct '31, p 679-81. Practise of Southern Pacific Lines, Houston, Tex.; joining sheets in locomotive firebox by electric arc process. (To be concluded.)

**Machines, Spot.** Heavy-Duty Spot-Welding Machine. *Engineering*, v 132, Oct 23, '31, p 539. Machine by British Insulated Cables, Ltd., is suitable for making welds up to ½ in. in diam. in two or more pieces of mild steel having total thickness up to ¾ in., and at speeds up to 600 welds per hr.; comprises 60-kw. single-phase, air-cooled transformer.

**Machinery Bases.** Reducing Weight and Production Costs, C.M.Taylor. *Welding Engr.*, v 16, Sept '31, p 58-60. How bending brake and electric arc work together to improve design of machine bases and cut cost of manufacture.

**Machine Tool Manufacture.** Machine Tool Frames Produced by Welding, J.R. Weaver. *Machy.* (*N.Y.*), v 38, Nov '31, p 171-3. Principles governing construction of machine tool frames and bases by arc welding illustrated by examples.

**Pipe.** Welding of Copper and Brass Pipe, H.V.Inskeep. *Am. Welding Soc.—Jl.*, v 10, Oct '31, p 21-4. Research work at Union Carbide and Carbon Research Laboratories to determine best types of joint.

**Pipe Joints.** Four Problems Encountered in Flash Welding Mild Steel, E.R.Torgler. *Am. Welding Soc.—Jl.*, v 10, Sept '31, p 29-33. Welding methods in manufacture of Dresser type couplings of 8 to 26-in. diam. with particular regard to flash welding of mild steel middle ring; determination of necessary flash and upset (burn and jam) for satisfactory middle ring flash weld; photomicrograph illustrates structure; secondary piping and segregated impurities as causes of defective flash welds; comparison between flash weld and roll weld.

**Pipe Lines.** Welded Pipe and Fittings in Heating Installations, F.J.Maeurer. *Am. Welding Soc.—Jl.*, v 10, Sept '31, p 5-13. Efficiency; economy; weight saving; fabrication of joints; fabrication of headers; welding fittings; spacing and tacking; expansion and contraction; adaptability and portability of oxyacetylene apparatus; welding piping in home; reduction of friction loss in welded fittings.

**Rails.** The Electric Welding of Battered Rail Ends. *Engineering*, v 132, Oct 2, '31, p 452. Canadian Pacific Railway authorities have been experimenting, during past 3 years, in hope of developing economical means of building up battered rail ends by electric welding.

Committee on Welded Rail Joints—Progress Report No. 7. New York, American Bureau Welding, A.E.R.E.A. and U.S. Bureau Standards. May '31, 62 p. Outline of following Bureau of Standards progress reports: Preheating and Postheating; Hardness Tests Along Thermit Welded Unit; Hardness Tests Along Thermit Welded Rail Joint; Metallographic Examination of Thermit Welded Rail Joint; Results of Shearing Tests of Small Preheated and Postheated Welded Specimens of Investigation No. 3 Revised; Repeated Impact Tests of Rail Joints of Investigation No. 2.

**Structural Steel.** Jig Assembly for Welding Fabrication Proves Its Efficiency. *Eng. News-Rec.*, v 107, Oct 29, '31, p 688-9. Fabrication of steel for new all-welded shop building at Barberton, Ohio, plant of Babcock & Wilcox Co.; results showed 10 per cent saving over estimate for riveted building.

Report of Structural Steel Welding Committee. *Am. Welding Soc.—Jl.*, v 10, Oct '31, p 25-42. Investigation extending over period of 5 years; determination of stresses that may be safely used in designing of welded steel structures fabricated under ordinary commercial fabricating shop conditions. (To be continued.)

### WELDS

**Testing.** Stethoscopic Examination of Welded Products, J.R.Dawson. *Power Plant Eng.*, v 35, Oct 15, '31, p 1016-17. Hammer tests can be effectively used on welds; testing equipment and procedure. Before Am. Welding Soc and A.S.T.M.

**X-Ray Analysis.** X-Ray Examination of Welded Pressure Vessel Seams, A.J.Moses. *Combustion*, v 3, Sept '31, p 17-20 and 35. With recent formulation of A.S.M.E. code for welded boiler drums, technique and methods of testing used in manufacture of welded drums have taken on added interest and importance; outline of X-ray method of testing; features of installation of X-ray equipment which is representative of latest development in this field.

### WHEATSTONE BRIDGE

A Voltage Selective Nonlinear Bridge, C.G. Suits. *Physics*, v 1, Sept '31, p 171-81. Important property of simple series resonance circuit employing resistance, capacitance and iron core reactor arranged to saturate is abrupt increase in current at certain critical voltage; this phenomenon is identified as quasi-resonant condition, and is compared to resonance in linear circuits; experimental study is made of nonlinear bridge circuit comprising two branches of above type.

**Capacity.** Two Precision Condenser Bridges, A.Campbell. *Phys. Soc.—Proc.*, v 43, Sept 1, '31, p 564-8. To facilitate direct reading of both capacitance and power-factor, the author has developed two bridge systems, based on that of Carey Foster.

# Industrial Notes

**Westinghouse and Italian Company to Exchange Patents.**—According to F.A. Merrick, president of the Westinghouse Electric & Manufacturing Company, an agreement has been concluded with Ercole Marelli & Company of Milan, a leading Italian electrical manufacturing concern, for an exchange of patents and experience. The Westinghouse companies will not participate financially nor take any part in the management of the Italian company.

**Square D Promotions.**—G. Lewis Hull, sales manager, switch and panel division of the Square D Company, announces the appointment of C. W. Bates, formerly Chicago branch manager, as assistant sales manager. G. S. Blomgren, of the Chicago office, succeeds Mr. Bates as Chicago branch manager. Mr. Bates' headquarters will be at the Detroit factory of the Square D Company.

**The Corning Glass Works, Corning, N. Y.,** has appointed the Bra Bon Electric Company, Inc., with offices in the Lewis Tower Building, Philadelphia, as agents for the sale of PYREX power insulators. The territory covered will include parts of New Jersey, Pennsylvania, Maryland, District of Columbia and the states of Delaware and Virginia.

**Herbert S. Glasby,** who has been associated with the Acme Wire Company, of New Haven, Conn., has opened a sales office at 123 South Broad Street, Philadelphia. In addition to handling the line of magnet wire, coils, varnished insulations and condensers made by the Acme Wire Company, he will represent the National Harris Wire Company, of Newark, N. J., manufacturers of high resistance alloy wires and ribbons; the MacAllen Company, of Boston, producers of mica sheet, tapes and molded articles, and the Waterbury Button Company, Waterbury, Conn., makers of bakelite, durez and other high dielectric molded products.

**A New Time Switch.**—The Sangamo Electric Company, Springfield, Ill., has announced for January deliveries a very moderately priced, electrically wound time switch. The main spring, kept wound by a constant speed a-c. motor, has ten hour reserve power to carry through any ordinary current interruption. A jeweled balance with non-magnetic, non-rusting, temperature compensating, special alloy hairspring, guarantees dependable timing. One of the unique features of this new switch is the type of mechanical contact which is being introduced in this country, after being used successfully abroad for many years. This new contact has a slow opening and a small gap. It is revolutionary, but has been thoroughly tested and is guaranteed by the makers. The standard switch has levers for three complete daily operations, allowing for either one, two, or three, on and off periods each day. Manual operation does not affect the sequence of subsequent operations. A Sunday and holiday cutout is also supplied. The entire timing and winding mechanism is enclosed in a dust-proof case. This unit, complete with contact mechanism and molded bakelite connection block, is mounted in a pressed steel case.

**An Improved Lamp Cord.**—The Simplex Wire & Cable Company, Boston, has introduced "Latox" rubber sheathed twin lamp cord, a new type of flexible, rubber insulated cord suitable for portable lamps, fans, clocks, toys and similar apparatus. It is a small, durable cord with a thin covering or sheath of tough, new type, rubber compound in place of the usual silk, rayon or cotton braids. The rubber sheath is furnished in black, green, or brown-mahogany and retains a satin-smooth, highly polished finish indefinitely. The advantages claimed for the new cord are that it will never fray, it does not gather dust or lint, is sanitary, will not absorb moisture, and wiping with a damp cloth restores its freshness when soiled.

# Trade Literature

**Instrument Transformers.**—Catalog GEA-601C, 42 pp. Describes General Electric standard lines of switchboard, portable and laboratory instruments. Dimensions and typical scales of certain lines are included. General Electric Company, Schenectady, N. Y.

**Illuminating Equipment.**—Bulletin, Serial No. 754, 28 pp., "Planned Lighting," described as a comprehensive manual for planning almost every form of illumination. Illustrated and includes detailed sketches and data on wattage capacities. Curtis Lighting, Inc., 1123 W. Jackson Blvd., Chicago.

**Motors.**—Bulletin 167, "Small Motors," 30 pp. The bulletin, in loose-leaf form, is divided into eight parts describing single-phase, polyphase and direct-current motors in fractional horsepower ratings. At present only five of the eight parts are available, but the missing three parts will be mailed at a later date to all who request a copy of No. 167 at this time. Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis.

**Illuminometer.**—Bulletin 4 pp. Describes a new instrument which reads illumination intensities with the same ease and facility as reading ammeters and voltmeters. Known as the Model 603 Illuminometer, it consists of an indicating instrument and a light target assembled in a portable case. The light target is on the end of a flexible cord so that it may be placed in any position. This light target, or searching unit has two photronic cell units which convert light energy directly into electrical energy without the use of batteries or other auxiliary voltage. They maintain constant output over long periods of time and there is no dark current. The output from the photronic cell units is considerable, allowing the use of a rugged portable instrument calibrated directly in foot-candles. There are three ranges on the instrument, namely, 10, 50 and 250 foot-candles. A range changing switch is provided for the selection of the desired scale. Other combinations of ranges are being added to the line and will be available shortly. The light target may be placed at a distance from the observer so that shadows and lights reflecting from light clothing will not cause errors in readings. Light may be read from all angles and the light target may be placed in relatively inaccessible places, in show cases, windows, etc. The absorption of light by painted walls, screens draperies, etc., can be measured directly by turning the light target so that it faces the surface. The time required to make a lighting survey is about one-tenth of that previously required. Weston Electrical Instrument Corp., 584 Frelinghuysen Ave., Newark, N. J.

**Bus Connectors.**—Catalog 31, 96 pp. Describes "Memco" bus connectors and ground fittings. In addition to conventional designs of clamped and soldered bus connectors, two original and unique designs in clamped connectors are presented. One is the "Pliaband" design, which is a bolted connector, so designed as to adapt itself to the minor irregularities and variations in the circumference of the bus. It is primarily a high capacity fitting for important connections. The "Wedge-Grip" connectors are, as the name implies, based on the use of high pressure contact as secured from the wedge principle. Each connector of this type accommodates from eight to twelve sizes of wire and cable. In addition, a complete line of fittings are listed for modern "flat type" substations. The engineering section of the catalog contains a number of original tables and charts which will be found very helpful as short cuts in substation design work. It also includes the principal NEMA standards as relating to outdoor substation practise. Memco Engineering & Manufacturing Co., Inc., 37 Ninth Street, Long Island City, N. Y.

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A modern transmission tower in New England.
Photo Courtesy Arthur Palme (A'17-M'25) Pittsfield, Mass.

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**M**ANY factors affect the precipitation efficiency of Cottrell smoke treaters. *p. 93-95*

**T**HE engineer is said to be the man most needed by the world today. *p. 107*

**C**ORRESPONDENCE is invited upon any of the articles appearing in ELECTRICAL ENGINEERING. *p. 138*

**W**ELDING is represented in this issue by the description of a completely self-contained d-c. arc welding generator. *p. 108-111*

**P**HOTOELECTRIC recorder achieves high sensitivity by not requiring its indicating element to perform recording duties. *p. 114-116*

**L**ONG distance telephony has introduced time problems in voice transmission which are extremely difficult to solve. *p. 89-93*

**M**ANY prizes are awarded annually by the Institute for the best papers presented at conventions and district meetings during the year. *p. 134*

**A** BIBLIOGRAPHY on transmission line conductor vibration has been prepared under auspices of the A.I.E.E. power transmission and distribution committee. *p. 135*

**S**HOULD the field switch of a loaded alternator be opened accidentally, tests show that service should be restored by simply reclosing it as soon as possible. *p. 119-120*

**H**INGED wooden arms on a steel-tower transmission line with eleven insulator units in each string provide line insulation equivalent to from 17 to 23 units on steel arms. *p. 121-128*

**G**REAT Lakes District (No. 5) of the A.I.E.E. meets in March; a tentative technical program has been arranged. *p. 133*

**D**EFINITION of power system terms, to avoid confusion in stability and interconnection studies, should be reduced to a uniform basis. Proposals of the Institute's special committee on this subject have been submitted. *p. 106-107*

**W**INTER convention papers not abstracted or otherwise treated in the January issue of ELECTRICAL ENGINEERING are abstracted briefly in this issue. *p. 130-132*

**I**NSTITUTE members were active in the recent annual meeting of the American Engineering Council in Washington, D.C., when three past-presidents were elected to important offices. *p. 137*

**F**RANK J. Sprague was elected recently to Honorary Membership in the A.I.E.E. as "the outstanding pioneer in the development of electric traction." *p. 139*

**I**NSTABILITY of Conowingo hydro plant was remedied by the installation of high speed relays and circuit breakers, and by changes in the operating set-up. *p. 95-102*

# Present Practise in Insulated Power Cables

Essential characteristics and latest developments in power cables are reviewed briefly in this article. Consideration is given to the three principal insulation materials, to different types of cable, and to impregnating compounds. In addition to summarizing present power cable practise in this country, future trends are indicated.

By
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Fellow A.I.E.E.
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New York, N. Y.

IN CONSIDERING power cables we naturally think of three types of insulation: rubber, varnished cambric, and paper. There are quite definite limits for each type, governed principally by their electrical and physical characteristics as influenced by economics. The comparative merits of the three types of insulation will be considered first, and then each will be discussed separately. The general characteristics of the three types are presented in Table I in an illustrative manner.

The standard specifications which previously have been generally accepted for rubber compound used on insulated wire prevent manufacturers from using certain well-known and desirable ingredients. These specifications in the past have demanded a chemical test to prove that the compound contains a stated percentage of rubber. Materials which have been largely responsible for the advance of the rubber industry in other lines and for the saving of millions of dollars yearly have been prohibited for use in cables, merely because certain very advantageous ingredients interfere with the chemical tests for percentage of rubber. In recent years it has been realized more and more clearly that great advances could be made if rubber insulation could be judged not by chemical analysis of ingredients but by tests which show its performance and give an indication of its length of life.

While probably no tests will prove definitely that a certain compound will have a life of ten years or thirty years, tests have been developed which so closely simulate service conditions that they are entirely adequate to prove that one insulation will have a much longer life than another. These tests, are: first, the Geer test in which test samples are suspended in an oven at 158 deg. fahr. and hot fresh air is allowed to circulate; and second, the oxygen-bomb test, usually considered superior to the Geer test, and based on the fact that deterioration in rubber compound usually is due to oxidation. The samples are placed in a bomb filled with oxygen under 300-lb. pressure at 158 deg. fahr. In both the Geer and bomb tests, samples are taken out and are tested for tensile strength and elongation, the resulting values being plotted against time. A third and valuable form of test is the ozone test, in which rubber-insulated conductors in various forms are placed near a grounded metal plate and a sufficiently high voltage applied to cause the breakdown of the air external to the rubber, thus exposing the insulation to the action of ozone.

Table I—Characteristics of Cable Insulation

| | Rubber | Varnished cambric | Paper |
|---|---|---|---|
| Moisture resistance | Very High | Fair | Hygroscopic |
| Max. allowable temperature | 60 deg. cent. | 75 deg. cent. | 85 deg. cent. |
| Can be bent to | 6 diam. | 8 diam. | 12 diam. |
| Affected by corona or ionization | Yes | Resists | Resists |
| Life | Fair | Long | Long |
| Power factor 60 deg. cent. | 5% | 6% | 1% |
| Installation and jointing | Very easy | Easy | Requires care |
| Can be used non-leaded | Yes | Yes (indoors) | No |
| Dielectric strength in volts/mil for 1 hr | 250 | 250 | 400 |
| Standard test voltages in volts/mil | 70 | 125 | 200 |
| Specific inductive capacity | 3.5 to 6 | 3.5 to 6 | 3 to 4 |

Typical curves obtained by the oxygen bomb test are shown in Fig. 1. It will be seen that the standard specification of the A.R.A gives a compound which deteriorates rapidly, while a performance compound containing 30 per cent rubber judged by the performance standard rather than by chemical tests is affected very little, and a special heat-resisting stock is hardly changed at all. The N.E.L.A. and the A.S.T.M. lately have adopted tentative standards for judging rubber compounds by performance tests rather than by purely chemical tests. These undoubtedly will make future progress more rapid and will result in a large economic saving to the electrical industry.

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Written especially for ELECTRICAL ENGINEERING and based upon a talk presented before the power group of the Institute's New York Section. *Not published in pamphlet form.*

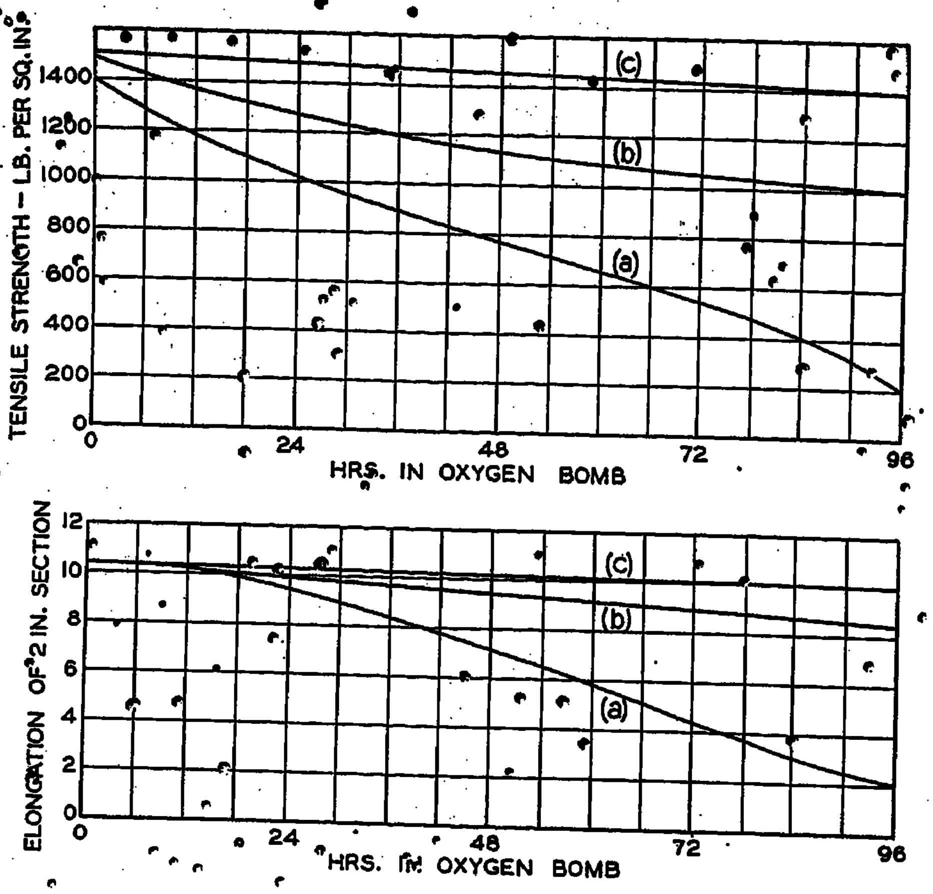

Fig. 1. Aging characteristics of rubber compounds as shown by the oxygen bomb test performed at 158 deg. fahr. and 300-lb. pressure

(a) A compound containing 30 per cent rubber as shown by the chemical tests of the American Railway Association
(b) A compound containing 30 per cent rubber, but in which the percentage of rubber cannot be checked by chemical tests
(c) Compound same as (b) except that it has been specially compounded to meet high temperature conditions

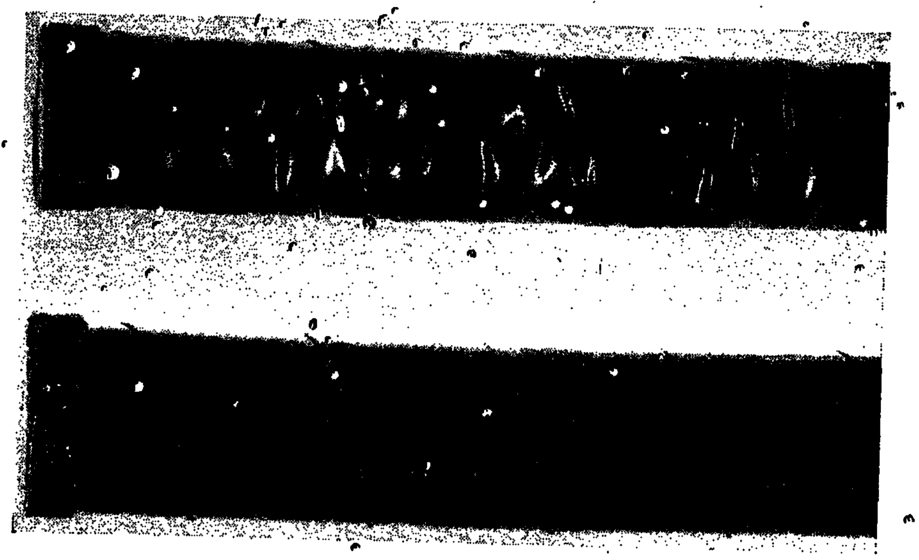

Fig. 2. Butted construction (below) of applying varnished cambric tape has characteristics superior to overlapped construction (above)

**Table II—Insulation Recommended for Station Cables**

| Nominal system voltage | | Preferred insulation for non-leaded cables | |
|---|---|---|---|
| From | To | First | Second |
| 0.... | 600 .. | Rubber........... | |
| 601.... | 4,000 .. | Rubber........... | Varnished cambric |
| 4,001.... | 13,200 .. | Varnished cambric. | Rubber |
| 13,201.... | 17,000*.. | Varnished cambric. | Paper (lead-covered) |

*At voltages higher than 17,000 volts, paper-insulated lead-covered cables should be used.

Varnished cambric has a higher dielectric loss than now obtainable with paper, and due to the method of manufacture, contains some air and moisture. The present trend is toward a reduction in the dielectric loss as well as a different application of the tapes so that wrinkles and voids will be largely eliminated. Many years ago it was found necessary in the manufacture of paper cable to apply the paper tapes so that they butted instead of overlapped. Only recently this has been used on varnished cambric. These two types of tape application are shown in Fig. 2, except for the cases of small sizes of conductor and thin walls, the freedom from wrinkles in the butted construction increases the dielectric strength, greatly improves the ionization characteristics, and is undoubtedly an important step in the direction of improvement of varnished cambric cables.

Varnished cambric when leaded is more costly than paper and rarely is used for underground transmission. For station work, however, it is sufficiently resistant to moisture to operate without a lead sheath and terminals, and thus varnished cambric braided cable often has considerable advantage in cost over other forms. Table II shows recommended types of insulation for station cables.

Impregnated-paper insulated cable is used universally for underground transmission of large blocks of power and for high voltage work. It is not only the least expensive type of cable available for this purpose, but also it has by far the highest dielectric strength, longest life, and greatest reliability. For voltages of 33 kv. and over, it is at present the only type which can be used successfully and economically.

Up to a few years ago, multi-conductor cables were mostly of the belted type, a cross-section of which is shown on the left in Fig. 3. These cables proved fairly satisfactory for voltages up to 26 kv.; however, when it was attempted to use this construction at 33 kv., the belted cable was found entirely inadequate unless very heavy walls of insulation were used. It was proved that the weakness was not the insulation proper but the filler spaces. The filler material is inherently weaker than the conductor insulation, and furthermore, the stresses in the outer layers of conductor insulation have a component of force parallel to the layers, by far the weakest direction. Another weakness was that during motion of the cables, separation took place between insulated conductors, creating voids in the filler spaces. All these effects resulted in charring and burning of the filler spaces and outer layers of conductor insulation, often resulting in failure of the cable.

The solution to all these difficulties is the type *H* cable, so named from its inventor, Martin Hochstadter. The three-conductor type *H* cable is shown in the middle in Fig. 3. This design with a metal foil enclosing the conductor insulation prevents all the troubles of the belted cable because the filler spaces are completely shielded from electrical stress. Furthermore, the type

*H* cable has a considerable advantage in current-carrying capacity. In the first place, being electrically equivalent to three single-conductor cables under a lead sheath, it can be operated at the higher temperatures permissible for single-conductor cables. Secondly, copper has about three thousand times the thermal conductivity of paper. Copper foil therefore is very effective in conducting heat out to the lead, resulting in a reduced temperature rise of the copper above lead. The gain due to higher permissible temperature is independent of installation conditions and increases with working voltage. The increased current-carrying capacity for underground and aerial cables is shown graphically in Fig. 4.

The remarkable performance of type *H* cable has led to its practically complete adoption for voltages 20 kv. and higher in this country and abroad; in fact, it is in very general use down to and including generator voltages on the order of 11 kv. Due to the elimination of filler stresses, it is now possible to make multi-conductor cables for any voltage except where questions of diameter impose a limitation.

Type *H* construction is used also on single-conductor high-voltage cables, metallized paper being applied to the surface of the insulation as shown on the right in Fig. 3. The function of the metallized paper is to shield from all electrical stress, any voids which may occur between insulation and lead, such voids being formed when the cable is bent or when the lead sheath is stretched by the expansion of the compound under load cycles.

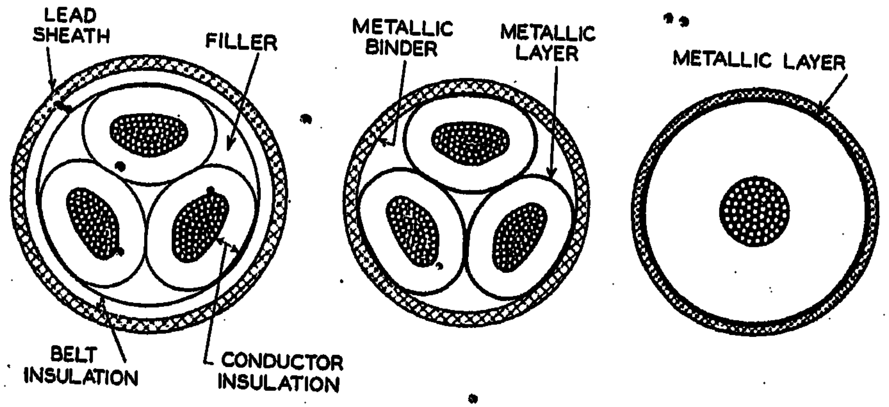

**Fig. 3. Cross-sections of belted cable (left), multi-conductor type H cable (middle) and single-conductor type H cable (right)**

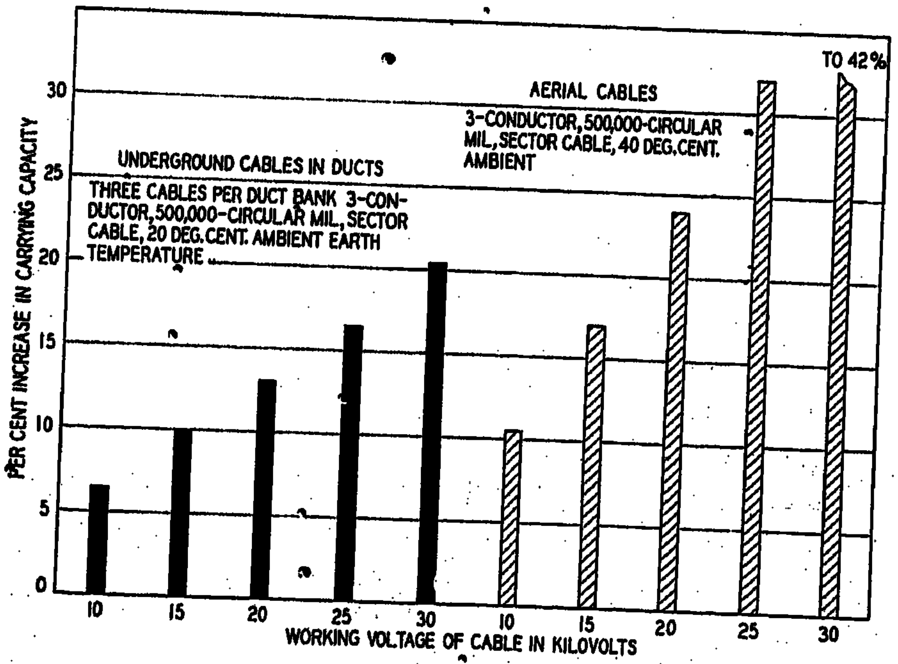

**Fig. 4. Increase in carrying capacity of type H over belted cables**

## A-C. RESISTANCE OF THREE-CONDUCTOR CABLE

Due to the recent use of larger and larger sizes of conductor in three-conductor cables up to 750,000 cir. mils for instance or even 1,000,000 cir. mils, it has become increasingly important to know accurately the effective a-c. resistance and reactance of such cables. These cables have additional losses due to skin effect, proximity effect, losses in the metallic binder tape, and in the lead sheath. The problem of these extra losses is important from the loss standpoint and from the standpoint of paralleling cables; it is being studied cooperatively by the Insulated Power Cable Engineers Association, some utilities, and the Electrical Testing Laboratories.

Some theoretical calculations made of losses, and which are quite close to actual measured values are shown in Fig. 5. It will be noted that the increase of a-c. effective resistance is considerable for the larger sizes. At first it was thought that the extra losses were in the magnetic steel binder tape used in type *H* cable. While final results have not yet been obtained and while

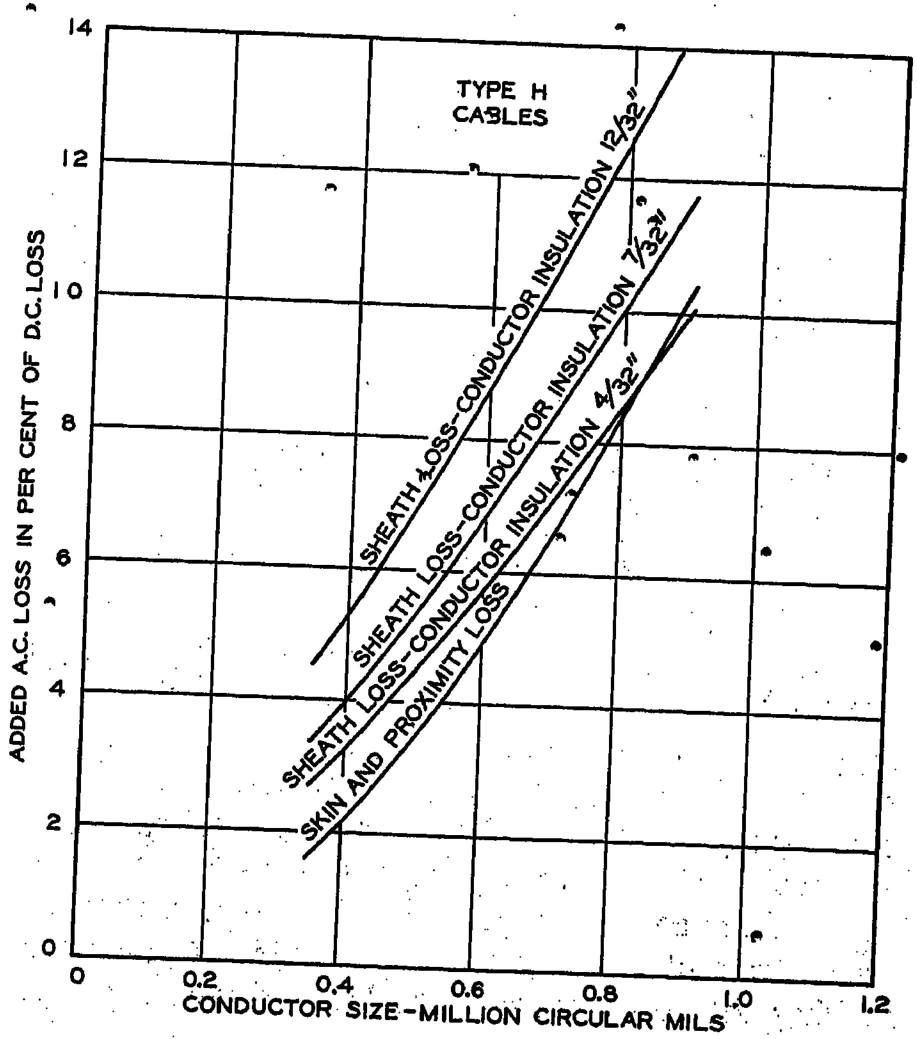

**Fig. 5. Added a-c. loss in three-conductor cables at 60 cycles and 20 deg. cent. Sector cable with 9/64-in. lead and non-magnetic binder tape**

Added a-c. loss = skin and proximity loss + sheath loss

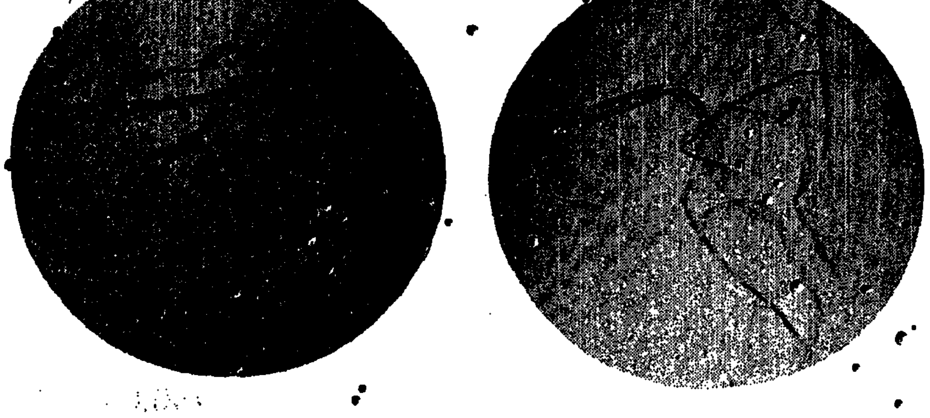

Fig. 6. Photomicrographs of fibers from ordinary wood pulp paper (left) and super-calendered wood pulp paper (right)

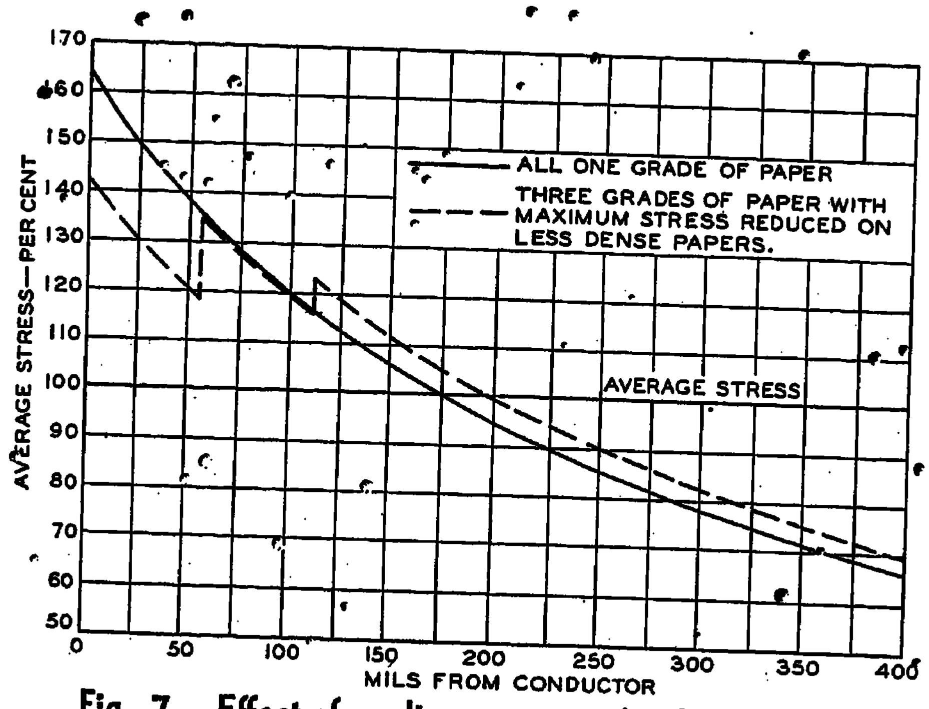

Fig. 7. Effect of grading on stress distribution with 4/0 round conductor and 406-mil paper

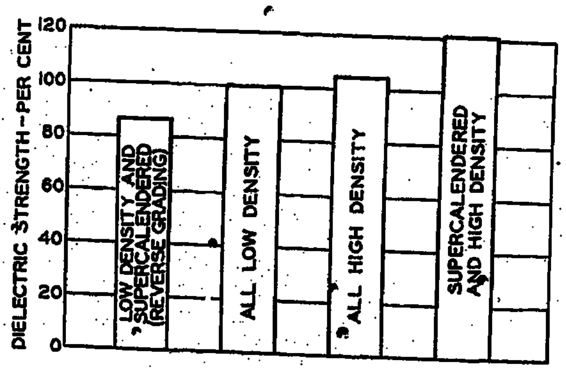

Fig. 8. Effect of grading on dielectric strength

there are differences from cable to cable, apparently at full load current there is very little difference in loss between a belted cable, a type *H* cable with a steel-binding tape, or a type *H* cable with a non-magnetic binding tape. Further, it appears that while there is a loss in the steel binder tape, its presence shields the lead sheath from some induction and thus reduces the losses by an amount about equal to the loss in the tape, thus making the total loss more or less independent of the type of construction.

Possibly the most important result of the study has been the emphasis that there is a considerable increase of reactance due to magnetic binder tape. The reactance of cables is so low that the increase is not of great importance in itself, but it is very important when studying the question of parallel operation of cables. The increased reactance ranges from an increase of 25 per cent in a three-conductor 350,000 cir. mil cable down to about 15 per cent for a three-conductor 1,000,000 cir. mil cable.

## MATERIALS

For many years most cable specifications required the use of manila rope paper, *i. e.*, paper made from fibers obtained from used manila rope. In recent years, however, wood pulp paper made by the sulphate process has been almost universally used in paper cable. It is usually made from Swedish pulp. This resulted in a great economy, and is responsible partially for the great increase in dielectric strength that has been evident in paper cables.

As the name implies super-calendered paper is paper which has been subjected to an additional calendering process which results in very dense paper having about 15 per cent higher dielectric strength and 30 per cent higher mechanical strength. Photomicrographs of ordinary and super-calendered fibers are shown in Fig. 6. The central channels apparent in the fibers of ordinary paper are not present in the super-calendered fibers, which are ribbon-like. The result is that for super-calendered paper there is no necessity for the difficult operation of eliminating the air and moisture in the channels of the fibers. Furthermore as can be seen from the pictures, the fibers are very much more closely packed together, with more fibers per unit volume, resulting in a greatly increased barrier action against all ions present, thus producing higher dielectric strength. Super-calendered paper also has a higher specific inductive capacity and with its higher dielectric strength, it is the ideal material to place next to the conductor where the stress is highest; it thus becomes possible to grade the insulation so that the maximum stress near the conductor is materially reduced. The improved stress distribution that may be secured is illustrated in Fig. 7.

The effect of using graded insulation, by which is meant the use of papers having different specific inductive capacities, is shown in Fig. 8. It will be seen that with super-calendered paper and high density paper there is an increase of 22 per cent over-all dielectric strength. The left-hand figure is of interest, showing that with reverse grading, *i. e.*, with super-calendered paper on the outside, the dielectric strength was reduced actually, as it is theoretically.

The breakdown strength of impregnated paper with its alternate layers separated by thin films of oil or compound is very much higher than the strength of either paper or compound alone; in fact, the electrical strength of impregnated paper is very much higher than that of any other materials available as cable insulation. In the early days, very viscous compounds composed of mixtures of rosin and rosin oil ordinarily were used.

These early materials, however, had high dielectric losses, and the next step was the use of mineral materials such as petrolatum, mixed with rosin. The insistent demand for still lower losses soon led to compounds of the nature of petrolatum thinned with transformer oil. Such compounds have low losses but some of them were not sufficiently stable chemically under the severe requirements of service. Mineral oils of the cylinder oil type which can be mixed with rosin or rosin oil and which have losses even lower than those obtained with the 100 per cent mineral compounds now are available.

There always has been more or less diversity of opinion as to relative merit of straight mineral oil or a mixture of mineral with rosin or rosin oil. The laboratories of the company with which the writer is associated have proved that high-grade rosin or rosin oil acts as an anti-oxidant when added to mineral oil in the proper proportion, mixed, and aged at the proper temperature. Rosin increases the stability of the resultant compound when subjected to dielectric stresses and its resistance to the so-called "wax formation" is greatly increased. It is of course necessary to select the proper grade of mineral as well as rosin oil so that the latter will remain in solution in the former. The photomicrographs in Fig. 9 show the appearance of proper and improper mixtures; the large undissolved crystals of rosin in the photomicrograph on the right are to be noted.

The effect of differences in impregnating compounds on the voltage-time characteristics of cable are shown in Fig. 10. Curve $X$ is for a compound containing no rosin or rosin oil; it was used several years ago but with great success. Curve $Y$ is made on cable insulated with a special mineral-oil rosin-oil compound. Note the slope of the curves as well as the fact that after two hours application of voltage they have about the same breakdown strength, whereas for long-time tests, there is a great gain for the one compound. Other things being equal, the superiority of compound $Y$ is quite obvious.

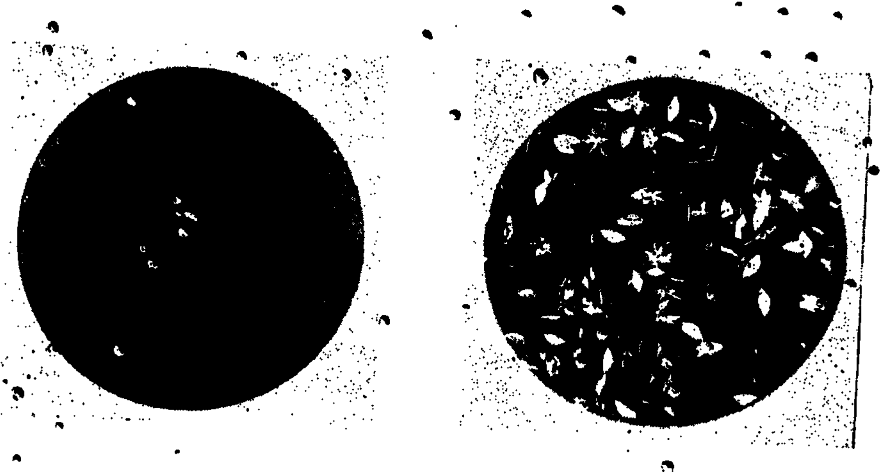
Fig. 9. Photomicrographs of different mixtures of impregnating compound

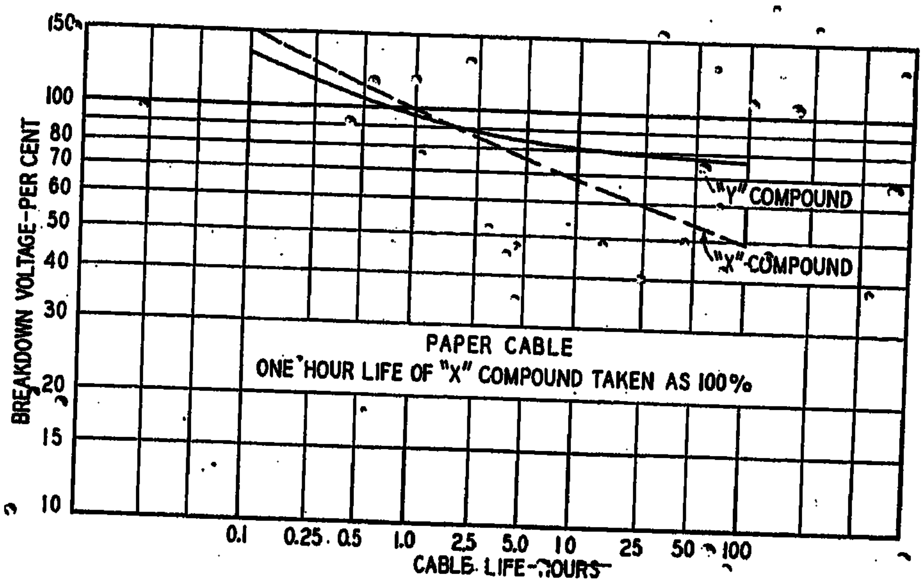

Fig. 10. Effect of different impregnating compounds on cable voltage-time characteristics

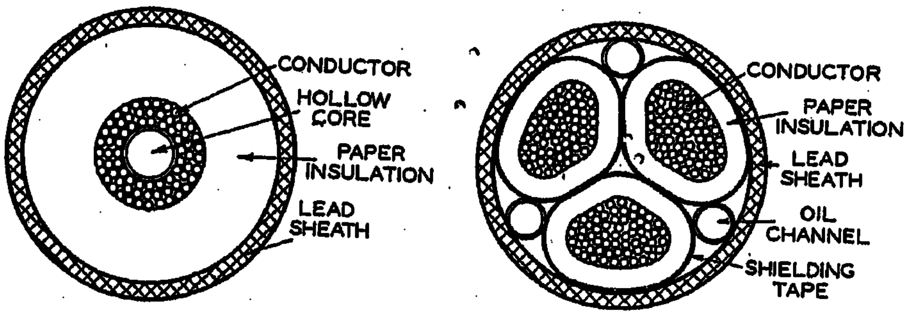

Fig. 11. Cross-section of single-conductor 132-kv. oil filled cable (left) and of three conductor 33-kv. type H oil-filled cable (right)

## OIL FILLED CABLE

The greatest and most spectacular development of cables for many years has been the advent of the oil filled cable. An ordinary cable is impregnated with what might be called an oil, but it is a fairly viscous oil which is not fluid at all operating temperatures, nor is the cable constructed to permit oil flow. Consequently, due to the large coefficient of expansion of the oil when the cable is heated, the compound will expand radially and stretch the lead. When the compound contracts, the lead will not contract and partial vacuums or voids are created in the insulation. This phenomenon is the main enemy of cable insulation.

In an oil filled cable, a thinner oil is used which is fluid at all operating temperatures; channels are provided for oil flow. When the cable is heated by load and the oil expands, the oil can flow lengthwise of the cable through the channel or channels of the cable into the joints and out into reservoirs. When the cable cools and the oil contracts, it is forced back into the cable by pressure on the reservoirs, and no voids are created. Cross-sections are shown in Fig. 11 of a single-conductor 132-kv. oil filled cable and a three-conductor 33-kv. oil filled cable. The subject of modern oil filled cable practise was covered in three papers recently presented before the Institute. Articles based upon these were published in ELECTRICAL ENGINEERING for November 1931, as follows: "Economics of High Voltage Cable," by D. W. Roper, p. 874-8; "Layout of Oil Filled Cable Systems" by G. B. Shanklin and F. H. Buller, p. 878-80; and "Accessories for Oil Filled Cable" by R. W. Atkinson and D. M. Simmons, p. 880-2.

The practical operating results obtained with oil

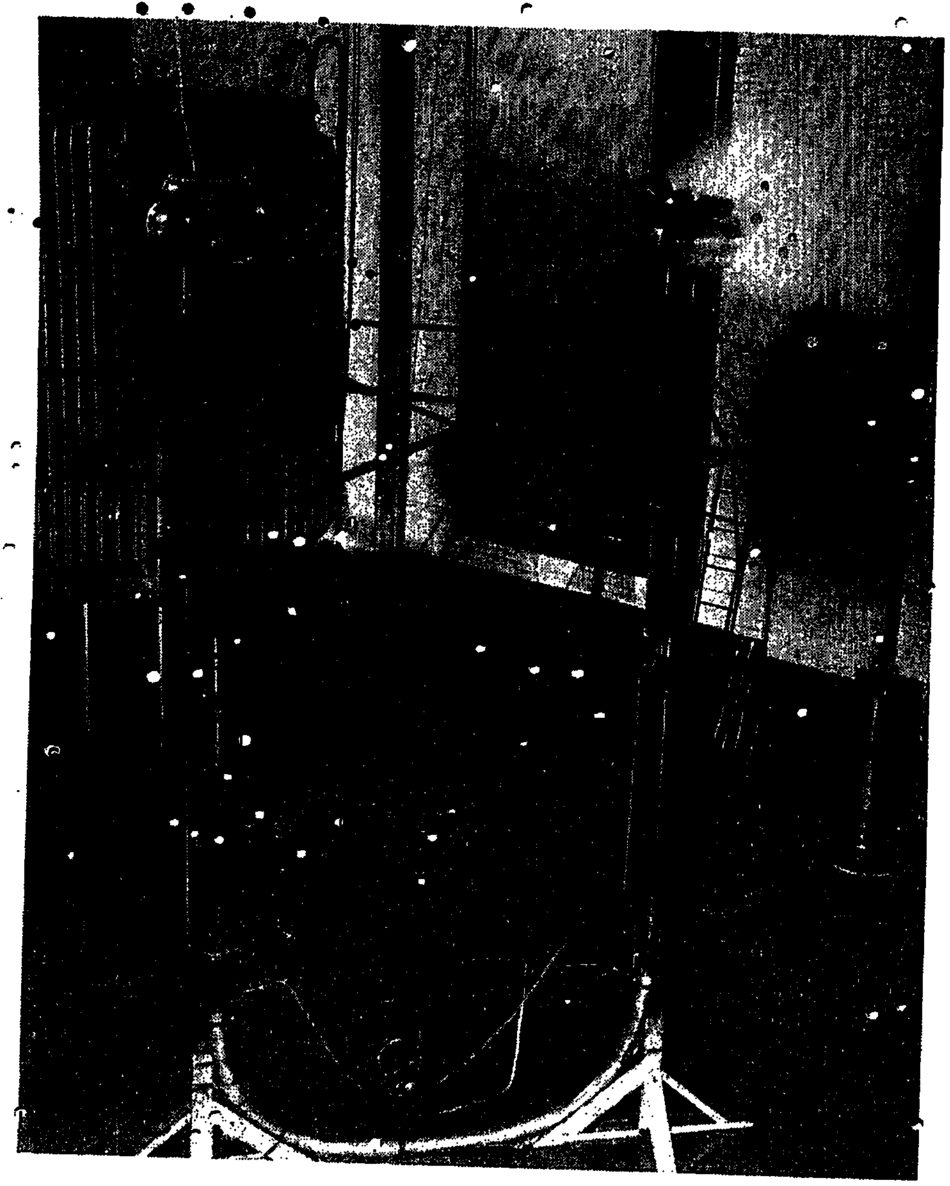

Fig. 12. Breakdown test on 220-kv. cable

filled cable as compared with the solid type have proved beyond doubt that the insulation thickness of cables for certain voltages can be reduced one-half while still maintaining a very high factor of safety, and with complete freedom from insulation failures; in fact, the present 132-kv. oil filled cables have slightly less insulation than have been used in this country for 66-kv. cable of the ordinary type. Furthermore, for the past year the Commonwealth Edison Co. of Chicago has had experimental lengths in operation at 132 kv. which have slightly less than 13/32 in. insulation thickness, or the same thickness as standard for 35-kv. cables of the ordinary type. These lengths have had load cycles heating the cable up to 70 deg. cent., and have performed even better than expected; in fact, the power factor and ionization which have been periodically measured have improved in service.

While at the present time there is no 220-kv. cable in service there is no question about the possibility of manufacturing and operating such cable when needed. The knowledge and experience gained on oil filled cable in service, on field tests and in the laboratory have demonstrated that without doubt, 220-kv. cable can be made to operate with as high a factor of safety as 132-kv. cable, without exceeding dimensions that are entirely practical. In so far as joints are concerned, the development of the condenser type joint with complete control of the distribution of stress makes it possible to design a joint with reasonable dimensions which will be as safe at 220 kv. as the present condenser joints are at 132 kv. The terminals will present no problem, and of course the external equipment such as reservoirs will be essentially the same as that in use at present.

A breakdown test made on a sample of 220-kv. cable is shown in Fig. 12. This cable was tested starting with 250-kv., 60 cycles between conductor and lead, the voltage being raised 25 kv. at one-minute intervals, up to 500 kv., and was held there for 10 minutes. The voltage then was increased by the same steps up to 675 kv., when an arc occurred to the building. A later test was carried to 725 kv., without failure of the cable or terminals. The series of condenser type terminals is of interest, each of three sections having been especially assembled to meet the extreme test conditions imposed by these high values of voltage. It is believed that this is the highest voltage ever applied to a cable.

## Carrying Capacity as Affected by Dielectric Loss

The curves in Fig. 13 are of interest and are self-explanatory. It will be seen that power factors which are obtained at the present time do not cause any serious loss in carrying capacity of cables in existing ranges of voltage. An examination of the curve for 330 kv., however, indicates that there will be some very difficult problems to solve in order to avoid undue reduction of carrying capacity due to dielectric loss when cables at this extreme voltage are required.

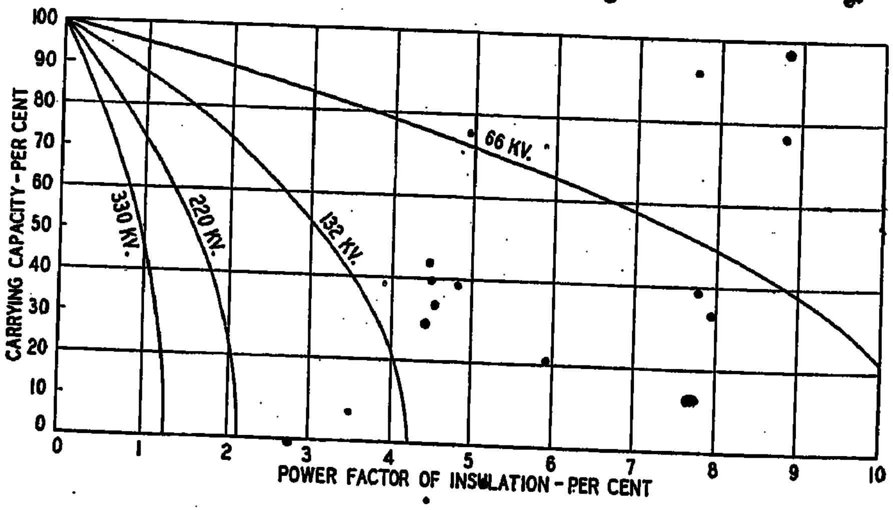

Fig. 13. Carrying capacity of oil filled cable as affected by dielectric loss. Capacity expressed in percentage of maximum possible

Curves are calculated on the basis of a 2,000,000-cir. mil single-conductor cable with one circuit per duct bank

## Future Trends

The road of a prophet is one of great difficulty and should be approached with caution. There are, however, some quite definite tendencies and trends apparent in the cable industry which has already entered a rather revolutionary stage. An illustration of the remarkable improvements that have been made by the cable manufacturers hand in hand with the utilities is the fact that in a short period of about six years from about 1921 to 1927, the maximum operating voltages of underground cables increased successively from 27 kv. to 33 kv., to 45 kv., to 66 kv., and up to 132 kv.

What made the last step possible and what makes still further progress possible is the advent of the oil filled cable idea. It should be emphasized that the oil filled cable has shown not only an ideal solution of all high voltage cable problems but it has demonstrated clearly the fundamental cause of early difficulties. It was well known that cable troubles from defective insulation, when they occurred, usually were due to deterioration caused by ionization and voids in the insulation. The writer does not believe, however, that there was any general appreciation of the fact that these voids were caused by the expansion and contraction phenomena of the cable compound with load cycles. The oil filled cable system is a complete cure to all these difficulties; however, now that the cause of the trouble has been thoroughly understood, cable engineers all over the world are searching for other solutions. If something could be placed in a cable which would expand and contract as the compound contracts and expands, void formation might be minimized. There is a multitude of new ideas on this subject, based on the fundamental idea that it is as illogical to make cables as they have been in the past as it would be to make a large bridge without an expansion joint.

Out of these many ideas involving large scale research, some practical results will doubtless evolve. In the opinion of the writer, the real oil filled cable will continue to be the ideal form. This is said primarily because not only does the oil filled cable completely take care of expansion and contraction phenomena of oils, but an oil filled cable has a degree of initial perfection that probably cannot be attained with any other form. Whether some of the special forms mentioned above will be economically justified in the middle-voltage range has yet to be proved.

Along with important developments in rubber and varnished cambric, undoubtedly the greatest future development will be in the increased economy with oil filled cables at present voltages, due to the reductions in insulation thickness and in cost of accessories which would make possible its use at lower voltages. At the same time we shall see oil filled cables at higher and higher voltages.

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# Time Factor in Telephone Transmission

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**Although the time factor in telephone transmission has been discussed in several technical papers, there seems to have been none giving a general over-all picture of the subject. Such a picture is presented briefly in this article.**

RAPID EXTENSION of the distances over which commercial telephony is given and the introduction of long telephone cables have introduced time problems in telephone transmission which are of great difficulty and technical interest.

The more important of these problems are the following: (1) The slowing down of conversation by the time interval between the formation of a sound by the speaker and its reception by the listener; (2) distortion of speech by the differences in the speed of transmission of the different frequencies which form it; (3) echo effects which arise from the reflection of energy at points of irregularity, particularly at the ends of a circuit; (4) interference with voice operated devices which may be connected in a circuit to overcome echoes or to stabilize the circuit; and (5) fading in radio circuits which may result from the different times of transmission of the signals over separate paths between the transmitter and receiver. This last matter, however, is outside the discussion of the present paper which is confined to the conditions where not more than one path is involved in the transmission in either direction.

The speed of transmission in which we are interested in this paper is that at which signals pass along the line. This may be quite different from the speed at which the crests or troughs of the waves travel along the line when a single frequency potential is applied continuously at the sending end. In fact in some forms of artificial circuit the crests and troughs may travel toward the sending end.

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Based upon "The Time Factor in Telephone Transmission" (No. 31-135) presented at the A.I.E.E. South West District meeting, Kansas City, Mo., Oct. 22-24, 1931.

## Table I—Speed of Transmission

| Type of circuit | Approx. speed miles/second |
|---|---|
| Cable circuits loaded with 88-mh. coils at 3,000-ft. spacing. | 10,000 |
| Cable circuits loaded with 44-mh. coils at 6,000-ft. spacing. | 20,000 |
| Cable pairs of non-loaded 16 B&S gage | 130,000 |
| Non-loaded open wire pairs | 180,000 |
| Radio | 186,000 |

Since the speed of signal transmission is generally different for different frequencies, we must consider at a time only a single narrow frequency range. We may suppose for convenience that electrical filters are applied to the circuit so that only frequencies within this narrow range can be effectively applied to it. If a voltage having a frequency, say, at the midpoint of this narrow range is applied to the circuit for a short interval and then removed, the speed at which the disturbance thus set up travels down the circuit is the speed in which this article is concerned. A spurt of energy of this type is evidently similar to that which takes place in a carrier telegraph system when a dot impulse is applied to the circuit.

On this basis the approximate speeds of a number of standard constructions which represent good engineering practise today are given in Table I. These figures are for bare circuits. In actual circuits the speeds are reduced 10 to 25 per cent by the apparatus necessarily inserted at the terminals and at intermediate points along the circuit.

Considering the first of the time problems listed above—that is, the slowing down of telephone conversation—it may be noted this does not interfere with one-way transmission. It does, however, slow down two-way conversation by the time required for the transmission of a question to the distant end and the time required for the return of the answer. Non-loaded open-wire, non-loaded cable, and radio are all sufficiently fast so that this effect does not interfere with their use for telephoning between any two places in the world. In fact this problem is not a pressing one for the largest distances within the United States even with loaded construction of the types now standard for long circuits. We must consider in the future, however, the joining together of long lengths of cable in this country and long lengths in Europe with possibly long lengths of intervening submarine cable. If two persons talked over a circuit of such great distances with the present types of loaded toll cables, each would feel that the other was somewhat sluggish in his replies.

Tests have been carried out to determine what magnitude of delays is permissible. Several methods of conveniently introducing delays have been employed in these tests. The method found the most useful is that illustrated by Fig. 1.

Two long brass pipes looped back and forth to conserve space are equipped with loudspeakers at their ends. One of these pipes is connected by means of its loudspeakers into the circuit for transmission in one direction, while the other is connected for transmission in the opposite direction. At the sending end of each pipe the loudspeaker converts the electrical energy into sound energy, and at the receiving end of the pipe the loudspeaker reconverts the sound energy back into electrical energy. Amplifiers and other control devices are used to give the desired transmission efficiency and to conserve the wave form. As great a time interval is required for 75 ft. of such transmission through air as for radio transmission half way around the world.

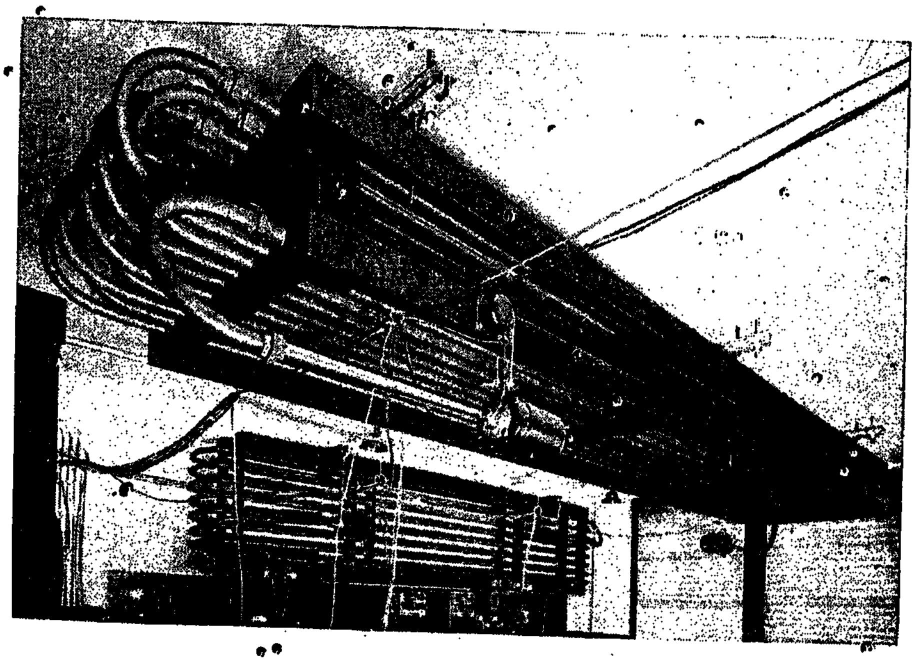

Fig. 1. Experimental acoustic delay circuit

Using devices of this nature, experimenters have found it possible to talk fairly conveniently over circuits representing time intervals as great as 0.7 sec. in each direction. Such great delays, however, would be considered undesirable for commercial use. Generally, delays of about one-third of this are considered the maximum which is satisfactory.

The second problem noted above is the distortion produced when the different frequencies making up speech are transmitted with different velocities. These effects may occur in one-way circuits as well as in two-way circuits and are not related to echo effects. The appearance of these transients to the listener depends on whether the excess delay is at low or high frequencies. It is rather difficult to describe the characteristic sound of a circuit with low-frequency delay. High-frequency delay, if extreme, sounds as though a high pitched reed, such as a harmonica reed, was being plucked whenever a sudden transition occurs in the voice sounds.

The appearance of such transients is shown conveniently by the aid of oscillographs of spurts of alternating current taken before and after being sent over circuits having various delay characteristics. If a frequency $f$ is suddenly applied to the sending end of a line, and if all frequencies are transmitted over the line with the same attenuation and at the same speed, the wave at the receiving end will duplicate exactly in form the wave at the sending end. Any departure of the line from these ideal characteristics causes transient effects at the receiving end as the incoming wave establishes itself, although ultimately the pure wave of frequency *f* is established.

An oscillogram is reproduced in Fig. 2 showing a spurt of 1,600-cycle current as applied to, and received from, a loaded cable circuit having fairly large delays in the upper part of the transmitted frequency range compared to the delay at lower frequencies. It will be observed that the current at the receiving end consists at first of a fairly low frequency which builds up in both frequency and magnitude to the steady state value. At the end of the spurt the same transient is experienced, but in this case the higher frequency currents which have been delayed more in the line are at the tail end of the train.

Transient effects of a particular type of a composited, loaded 19-gage cable circuit are shown in Fig. 3. The small variations in the zero line of the curves, due to cross-talk and other interferences, should be neglected. The upper line of the figure shows an applied 1,000-cycle current; the second line shows its form as it was received, disclosing transients; and the third line shows it at the reception point after it had been passed through a correcting network applied in series with the circuit. While the delay in the reception of the signal had been somewhat increased as indicated by the displacement of the signal further to the right, the transients at the beginning and ending of the signal are reduced very greatly.

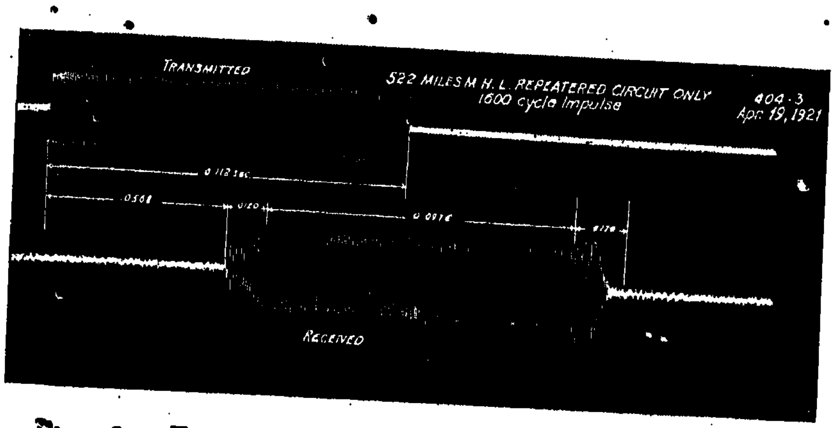

Fig. 2. Transients in medium heavily loaded circuit, showing delays in upper part of the range

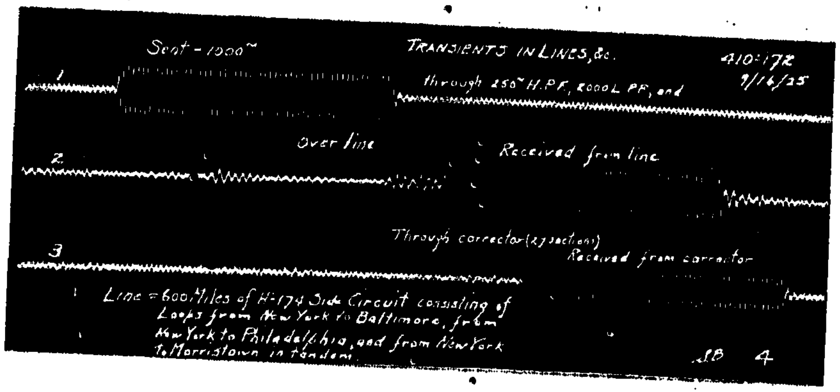

Fig. 3. Transients in medium heavily loaded cable circuit, showing effect of corrector

Excess delay at low frequencies may be present in a circuit due to the apparatus which is inserted in it.

The third problem listed includes the effects of echoes. Reflections of voice waves in all practical telephone circuits arise from impedance irregularities. It is only in telephone circuits of such length as to require a number of repeaters that echo effects become serious. The fact that the circuits are electrically long makes the time lag of the echoes appreciable. At the same time the telephone repeaters overcome the high attenuation and make the echoes louder.

Some of the reflected waves return to the receiver of the talker's telephone and if loud, may give him an uneasy feeling that the distant party wishes to interrupt. Other reflected waves enter the listener's telephone and if, severe, cause him to hear an echo following the directly received transmission.

The simplified diagram of Fig. 4 shows a four-wire circuit in which the effective echoes are limited necessarily to those caused by the two ends, since separate paths are used for east and west transmission. The lower part of the figure suggests the paths which the echo current may follow. The balancing arrangements used at the ends of such a circuit assist of course in keeping down the amount of echoes present.

A form of device used to overcome echoes is indicated in simplified form in Fig. 5. This figure will serve also to illustrate the fourth problem listed above; that is, interference with voice-actuated devices of this kind. The circuit shown is similar to that of Fig. 4 but with an echo suppressor so arranged that energy transmitted in one direction short-circuits and thus disables the path of the circuit going in the opposite direction. In this way echoes from the distant end cannot be transmitted back to the receiving end

If the delays in such a circuit are large and the adjustments not well made, it is possible for one subscriber talking fairly steadily to hold the suppressor operated so continuously that it is difficult for the other party to interrupt even if he so desires. Under similar conditions, if one subscriber starts to reply almost simultaneously with the termination of the other's speech, there may be some clipping at the beginning of his reply by the echo suppressor. More involved difficulties arise when there are two or more such devices at different points in a circuit.

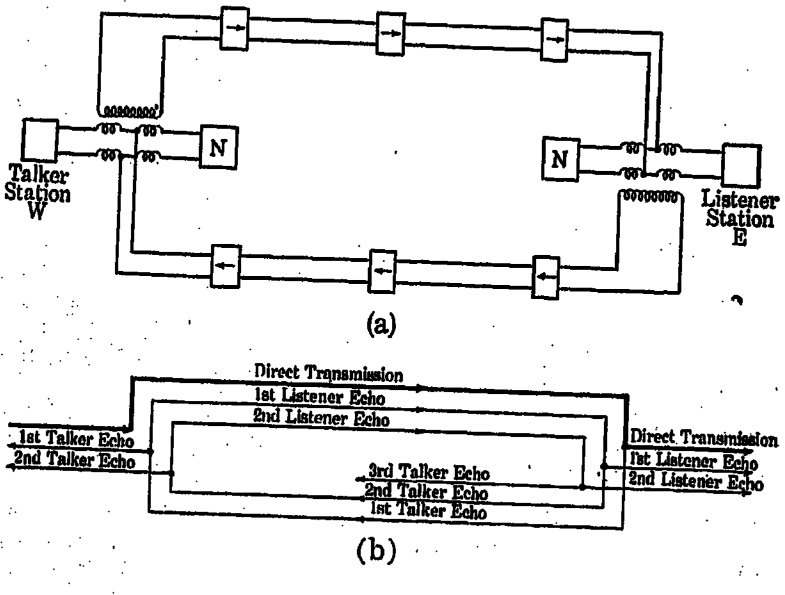

Fig. 4. Diagram of a four-wire circuit

Long radiotelephone circuits may vary so greatly in transmission effectiveness that if they were arranged to be operative in both directions at a time, it would be difficult to prevent their becoming unstable and setting up oscillations. Voice-actuated devices somewhat similar to echo suppressors but more elaborate are therefore employed on such circuits to stabilize them. With this arrangement the circuits leading to both radio transmitters are normally disabled. The speech waves starting from either end, therefore, must operate devices to put the transmitter at that end into working condition and to disable the receiving circuit at that end. Evidently arrangements of this kind need even greater care in design and adjustment to prevent clipping of speech and to avoid making interruption by the listener difficult.

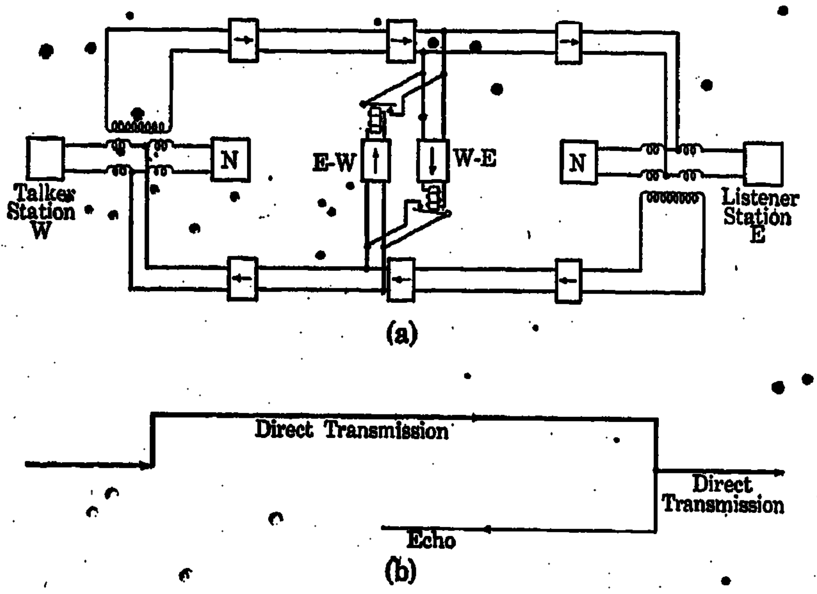

**Fig. 5. Four-wire circuit with echo suppressor**

An interesting application of time delay has been made in connection with radio systems so operated. In this the voice currents on reaching the disabling point are passed through an artificial line in which a desired amount of delay is incorporated. Just before entering this line a part of the energy is taken, rectified, and made to operate the switching mechanisms for restoring the circuit to operating conditions. This switching is completed by the time the voice currents have passed through the artificial delay circuit and are ready to proceed down the line. If it were not for this arrangement a small part of the speech currents might be lost during the interval while the switching mechanisms were operating.

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# Electrical Precipitation

**Although Cottrell smoke precipitators have found application in a variety of industries, theoretical features of the process and fundamental laws underlying it have not been subjected to very close scrutiny. Experiments described here were made to determine the effect upon "precipitation efficiency" of many of the variables entering into the process.**

By
A. W. SIMON

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Both of the
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COTTRELL TREATERS have found many applications in various industries for the recovery or removal of smoke, dust, and fume particles from their containing gases; yet the fundamentals of the process have received but scant attention. In order to put this process on a more quantitative basis an experimental and theoretical study was made in this laboratory, in which were investigated the effects upon the *precipitation efficiency* or percentage removal, of various fundamental variables such as the operating voltage, secondary current, gas velocity, concentration of the dispersoid, size of discharge electrode, and other factors.

The underlying theory of the process has been covered in previous publications, but for the purposes of this article, the following is quoted from "Electrical Precipitation of Solids from Smelter Gases," by Ross B. Rathbun, A.I.E.E. Trans., V. 41, 1922, p. 816:

> "This (the precipitation) is accomplished through the ionization of the gas which carries the particles in suspension. It is assumed that the negative ion or electron is the ionizing agent and that the velocity of the electron stream is sufficient to ionize the gas molecules by collision in a relatively small zone near the discharge electrode where the potential gradient is steepest. This stream of electrons in making its way toward the opposite electrode is assumed to charge the minute dust particles in passing by contacting or attaching to the particles. The latter having acquired a negative charge, and being in a strong electrostatic field, are attracted by the positive pole and hurled against it with considerable force, where they give up their negative charge to this electrode and cling to it (the electrode) by adhesion."

Thus the process may be seen to consist simply of passing the fume-laden gas through a unidirectional electrostatic field in which a corona discharge is maintained. The dust particles first are charged by the electric field and then swept out of the space between electrodes.

The theoretical development of the present article was based upon the assumption that the chance of a particle being precipitated depends merely upon its chance of encountering an ion, and this led to the equation

$$\eta = 1 - e^{-\alpha t} \tag{1}$$

where $\eta$ is the percentage removal (expressed as a fraction) $t$ the treatment time, $\alpha$ a constant for a particular precipitator treating a given fume or dust, and $e$ the base of the hyperbolic system of logarithms. This equation enables an immediate deduction of the effect of the distance $L$ traversed by the gas in the precipitator and the gas velocity $V$, since the time $t$ is merely the quotient of these two. This leads to the equation

$$\eta = 1 - e^{-\frac{\alpha L}{V}} \tag{2}$$

From eq. 1 also the effect of increasing the effective cross-section of a treater or its length, or the equivalent process of connecting similar treater units in parallel or in series, can be deduced immediately. Since time $t$ is the only variable factor appearing in the right-hand member of eq. 1, for a given constant gas volume treated per minute in a given number of precipitators, how these are connected has no import as regards the resulting efficiency, for the length of path is increased in a series connection in the same ratio as the velocity

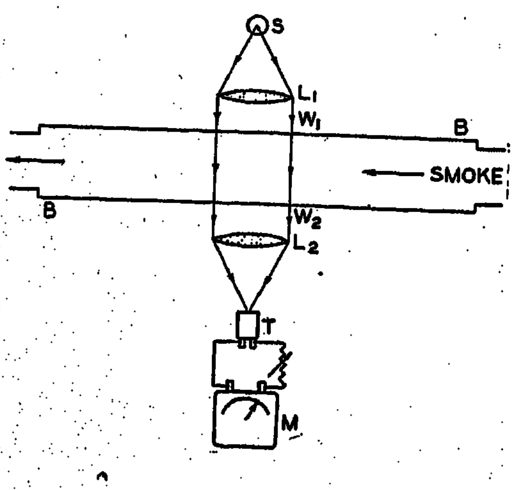

**Fig. 1. Special photometer for determining smoke concentration**

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From "Some Fundamental Theory and Experiments on Electrical Precipitation" (No. 32-32) presented at the A.I.E.E. winter convention, New York, Jan. 25-29, 1932.

is decreased in a parallel connection. In other words, a given number of units can be connected all in series or all in parallel without any difference in the theoretical efficiency. The same holds for symmetrical series-parallel connections.

## SPECIAL APPARATUS DEVELOPED

One of the chief difficulties in experimenting with the action of the Cottrell treater has been the lack of a quantitative method of determining the instantaneous dust or smoke content of the gas entering or leaving the precipitator. In these experiments this difficulty was solved by means of an optical (photometer) method; specifically, by measuring the light absorbed by a definite column of the smoke-laden gas. For a dust of constant composition and physical characteristics it can be shown that the concentration is proportional to the logarithm of the ratio of the incident to the transmitted light. The factor of proportionality depends upon the nature of the dust or smoke to be measured.

Apparatus used for measuring the dust concentration is shown schematically in Fig. 1. Light coming from small lamp $s$ is rendered parallel by the lens $L_1$, then passes through the window $W_1$ into a long rectangular box $B$ carrying the smoke-laden gas; from a second window $W_2$ on the other side of the box the light emerges, reduced in intensity by a fraction depending upon the concentration of the smoke; then by means of a second lens $L_2$ the light is concentrated on a light-sensitive element which sends a current through the meter $M$ proportional to the intensity of light acting upon it. Two such metering devices were used, one on the inlet and the other on the outlet side of the experimental precipitator.

The experimental precipitator used is shown diagrammatically in Fig. 2. It consists essentially of a cylinder (pipe) with an insulated wire electrode stretched inside along its axis. The wire is held in place by heat-resisting glass insulators at either end, the necessary corona-forming potential being supplied by a lead brought into the cylinder through a bushing also of heat-resisting glass. The high voltage supply consisted of a pulsating direct current obtained from a half-wave vacuum-tube rectifier.

For the material to be precipitated oil smoke was used, this being generated by a specially designed "smokifier" which allowed the formation of a constant stream of smoke of constant characteristics. This device consisted merely of a copper U-tube immersed in a molten lead bath; smoke was formed by simply feeding a thin stream of oil into the hot tube; the resultant smoke was blown out by a stream of air. Strictly speaking, this device generates an oil "mist" rather than a true smoke, the oil itself not being carbonized but merely vaporized and recondensed in the precipitator.

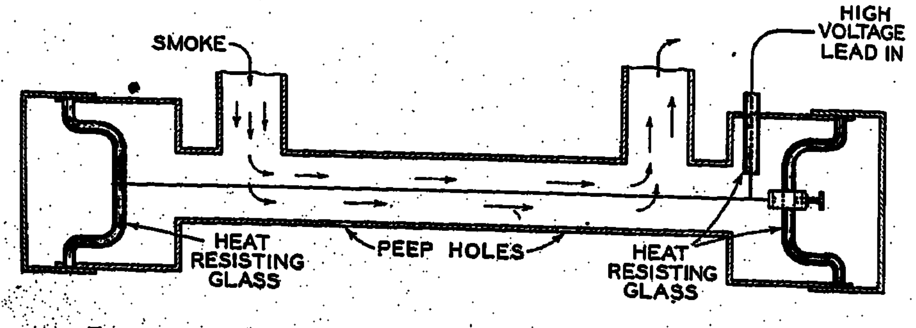


**Fig. 2. Cottrell electrical precipitator used in the experiments of this article**

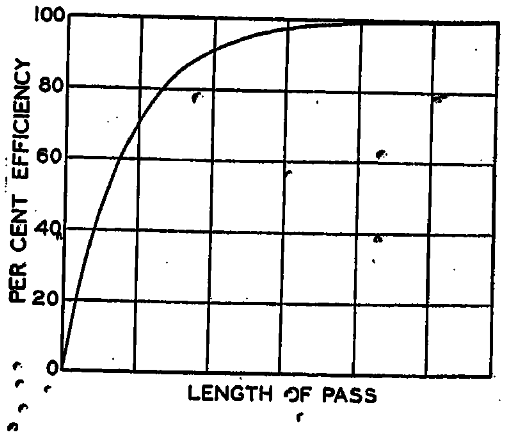
Experiments were carried out by passing the oil smoke first through one of the specially designed optical photometers where its initial concentration was observed; next the smoke was passed into the precipitator to which variations in the different factors involved in the investigation were applied. From the precipitator the gas was piped through a second optical photometer where its final concentration was observed.

## RESULTS

In general the experiments showed that the precipitation efficiency increases with the treatment time, voltage, current, and power, according to a curve which partakes of the nature of that for a condenser charge; or, in other words, they are exponential relationships. Curves representing these relationships thus rise steeply at first but at a continually decreasing rate; then bend over and eventually approach the value of 100 per cent efficiency asymptotically. This is depicted graphically in Fig. 3, which is a theoretical curve of the precipitation efficiency plotted as a function of the treater length. For a given gas volume treated per minute or constant gas velocity, the treater length is proportional to the treatment time. From this curve it may be seen that in general the cleaner a gas becomes the harder it is to make it still cleaner. After the first 90 per cent of the smoke particles has been removed, just as much additional apparatus is required to remove an additional 9 per cent of the original content than was necessary to remove the first 90 per cent, and so on. From the theoretical point of view this is due to the fact that the cleaner the gas becomes (that is, the smaller the concentration of the dispersoid) the smaller becomes the chance of a single particle of the dispersoid encountering an ion.

**Fig. 3. Theoretical precipitation efficiency of a Cottrell treater as a function of its length**

Curves for electrode voltage and current would have similar shapes



In addition to the general results just outlined, certain other peculiarities of importance were noted. Surprising as it may seem, the value of the operating voltage, in so far as it determines the electric field, apparently has but little effect upon the cleaning efficiency. The function of the field is only to sweep the particles, once they have become charged, to the collecting electrode; for this purpose over a wide range the exact value of the field and consequently of the applied voltage is of secondary importance. The same holds for the size of the discharge electrode; the latter merely determines the operating or corona-forming voltage.

Of fundamental importance, however, is the current flowing between electrodes and through the smoke-laden gases within the precipitator; and for different discharge electrodes and operating voltages it was found necessary only to duplicate the current to duplicate the precipitation efficiency. The current itself is affected by the concentration of the dispersoid entering the precipitator, being considerably depressed if the concentration is high, and *vice versa*. The resulting corona characteristic (current-voltage curve) of the precipitator under load thus depends upon the concentration of material entering the precipitator.

While the present theoretical and experimental study, upon which this article is based, is thought to be more extensive perhaps than most others that have been made before, it is considered to be still far from complete. It is hoped that the experiments described and the experimental methods developed will stimulate further research in this highly interesting field.

# Stability Experiences with Conowingo Hydro Plant

By

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**During the first year of operation, four cases of instability developed at Conowingo hydroelectric station of the Philadelphia Electric Company when faults occurred on the transmission lines. Subsequent investigations showed that some of the generators would advance 180 deg. ahead of the system in less than 0.3 sec. when full load was dropped suddenly. Installation of higher speed relays and circuit breakers together with changes in the operating set-up, have corrected the situation.**

STABILITY of electric power systems is becoming of more general interest and concern since the advent of large hydroelectric stations located at considerable distances from their loads, and with the general interconnection of large capacity power systems. Many papers and articles dealing with methods of calculating stability have appeared; but comparatively little information has been published showing the experience on actual systems. Such experience is of value as an indication of what may occur on other systems of similar character and also in determining the basis for design of new projects.

A typical example of a generating station susceptible to instability under certain conditions of severe line faults is the 252,000-kw. Conowingo hydroelectric station which is situated 58 miles from the main system of the Philadelphia Electric Company and ties in with that system and the 220-kv. Pennsylvania-New Jersey interconnection by means of two 220-kv. lines. During the four years the plant has been in service, studies of the stability of this system have been made, and considerable operating experience has been obtained including several cases of instability. As a result several changes have been made to improve system performance. Automatic oscillographs to record system performance during faults are installed permanently, and a great many records have been obtained. No operating tests to determine stability have been made, though several short circuit tests were conducted on the 220-kv. system to determine high speed relay and oil circuit breaker characteristics, these being intimately associated with stability.

### EXTENT OF SYSTEM INVOLVED

The system involved (see Fig. 1) consists of the Conowingo hydroelectric station with seven 36,000-kw.

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Based upon "Stability of Conowingo Hydroelectric Station of Philadelphia Electric Company System" (No. 32-25) presented at the A.I.E.E. winter convention, New York, Jan. 25-29, 1932.

generators connected by two 58-mile 220-kv. lines to Plymouth Meeting substation, a junction for two lines of the Pennsylvania-New Jersey 220-kv. interconnection, and for connection with the main part of the Philadelphia Electric system through step-down transformers. Three 10-mile 66-kv. aerial lines connect from Plymouth Meeting to Westmoreland substation, from which point lines radiate to the main part of the Philadelphia Electric system where most of the Conowingo output is used.

Pennsylvania-New Jersey interconnection as indicated consists of 220-kv. ties between the Philadelphia Electric Company system at Plymouth Meeting, the Pennsylvania Power and Light Company system at Siegfried, and the Public Service Electric and Gas Company system at Roseland. The interconnected systems are all of large capacity, having respective peak loads in 1930 of: Philadelphia Electric Company, 699,000 kw.; Public Service Electric and Gas Company, 540,500 kw.; and the Pennsylvania Power and Light Company, about 350,000 kw.

## PRELIMINARY STABILITY STUDY

Extensive stability calculations and studies were made before the 220-kv. system was built to check stability in case of line faults. The faults were assumed to involve only one phase since information then available indicated this to be the general experience on 220-kv. systems. These studies were based on the ultimate system development which involves extension as shown by the dashed lines in Fig. 1. Since the system is rather complicated, one of the studies was made with a mechanical model.[2] (For numbered references see bibliography.)

Results of the stability studies showed that in general synchronism could be maintained for practically all expected fault conditions, although considerable swinging was indicated for some conditions. On account of this swinging condition together with uncertainty regarding some of the factors assumed in the study, such as clearing time and fault resistance, it was considered advisable to incorporate in the design several special features for increasing stability.

Measures provided with the initial design, for increasing stability and reliability, may be divided into two general classes: (1) preventive and (2) remedial. The first class aimed to prevent faults by means of heavy insulation and protection against lightning with double ground wires for each line, shielding for substation structures, and installation of lightning arresters at the substation.[3,4] The second or remedial class included steps to clear faults quickly should they occur, and measures to stiffen the system in case of transient disturbances. In this connection a special relay system designed to clear all faults with minimum delay was installed. Oil circuit breakers used were designed to interrupt fault current in less than 0.5 second; at the time of their installation these were the fastest available

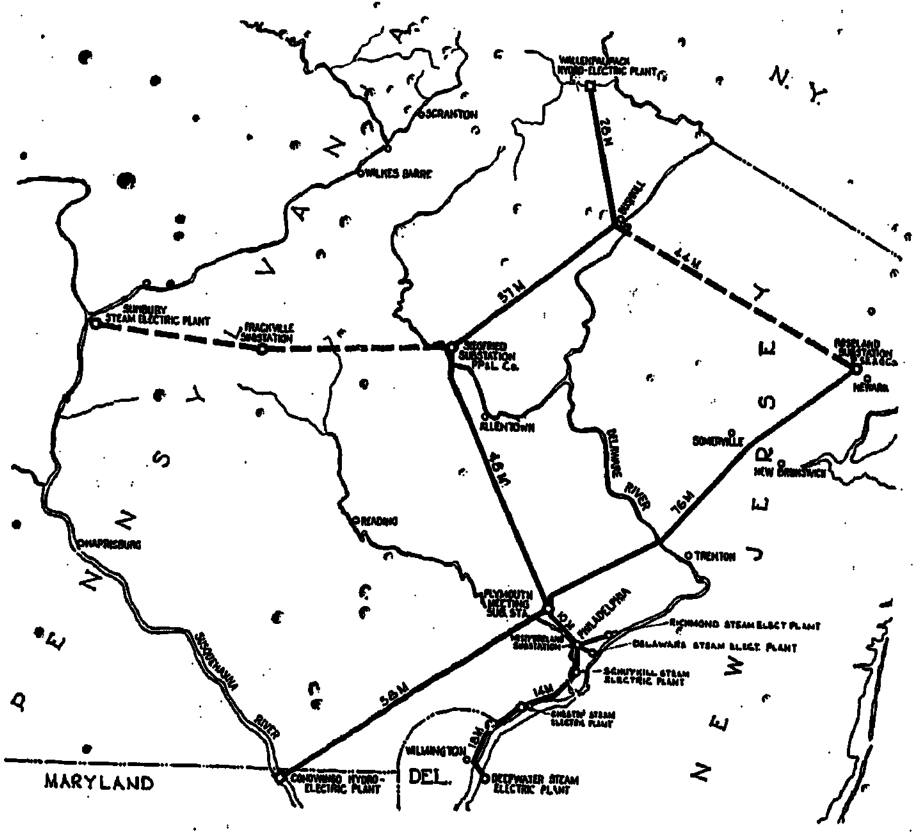
N. Y.
WALLENPAUPACK HYDRO-ELECTRIC PLANT
SCRANTON
WILKES BARRE
26 M
BUSHKILL
44 M
57 M
SUNBURY STEAM ELECTRIC PLANT
FRACKVILLE SUBSTATION
SIEGFRIED SUBSTATION PP&L Co.
ROSELAND SUBSTATION P.S.E.&G.Co.
NEWARK
ALLENTOWN
46 M
DELAWARE RIVER
SOMERVILLE
NEW BRUNSWICK
76 M
READING
HARRISBURG
TRENTON
PENNSYLVANIA
NEW JERSEY
PLYMOUTH MEETING SUB. STA.
10 M
PHILADELPHIA
WESTMORELAND SUBSTATION
RICHMOND STEAM ELECT. PLANT
DELAWARE STEAM ELECT. PLANT
SCHUYLKILL STEAM ELECTRIC PLANT
CHESTER STEAM ELECTRIC PLANT
SUSQUEHANNA RIVER
58 M
14 M
18 M
WILMINGTON
MARYLAND
CONOWINGO HYDRO-ELECTRIC PLANT
DEL.
DEEPWATER STEAM ELECTRIC PLANT

Fig. 1. Map of Philadelphia Electric Company high voltage system showing also lines of the 220-kv. Pennsylvania-New Jersey interconnection

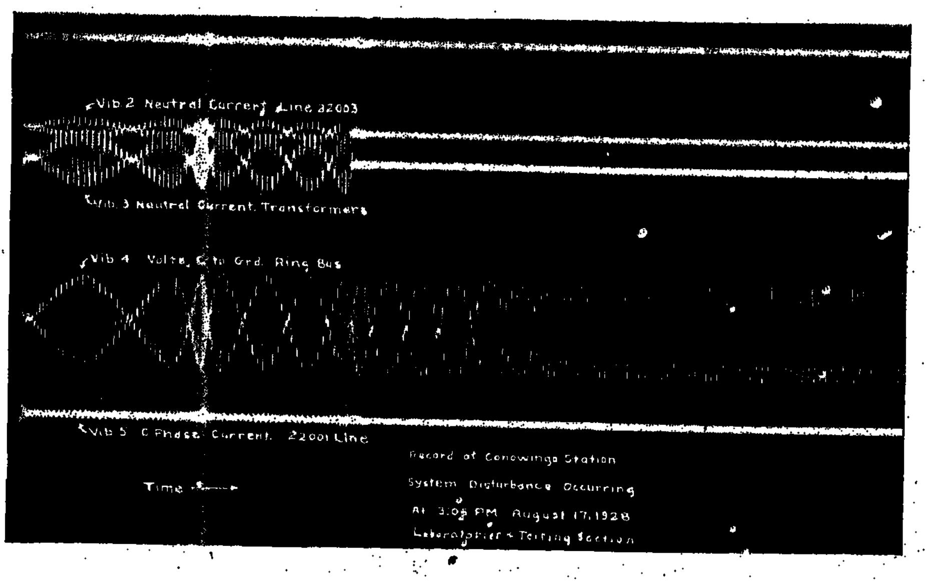

Fig. 2. Oscillogram of system disturbance August 17, 1928. Instability caused by two-phase fault on Conowingo line

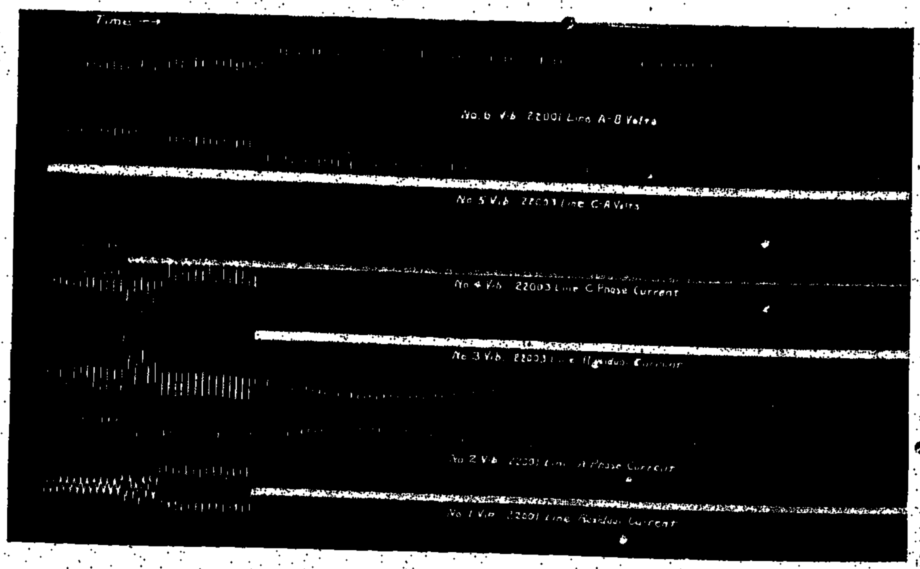

Fig. 3. Oscillogram of system disturbance January 14, 1930. Stability maintained through single-phase fault on Conowingo line (full station load)

## Table I—Faults on Plymouth Meeting-Conowingo 220-Kv. Lines

| Year | 1928 | | | 1929 | | | | 1930 | | | | 1931 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | 6–9 | 7–4 | 8–17 | 6–14 | 6–15 | 7–29 | 8–21 | 1–14 | 6–26 | 7–6 | 7–21 | 5–10 | 7–9 | 7–9 | 7–24 |
| Time | 5:27 p.m. | 4:12 p.m. | 3:06 p.m. | 11:48 p.m. | 1:21 a.m. | 4:12 p.m. | 5:06 a.m. | 12:31 p.m. | 7:48 p.m. | 7:19 p.m. | 7:14 p.m. | 8:52 p.m. | 7:41 p.m. | 9:01 p.m. | 1:47 a.m. |
| Cause | Ltng. | Ltng. | Ltng. | Ltng. | Ltng. | Ltng. | — | Ltng. | Ltng. | Ltng. | Switch failure | Ltng. | Ltng. | Ltng. | Ltng. |
| No. phases faulted | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 3 | 1 |
| Miles from Ply. Mtg. | 2 | 53 | 4 | — | — | — | — | 17 | 28 | — | 0 | 18 | 5 | 22 | 33 |
| *Residual amperes, Con. | — | — | — | Open | Open | — | Open | 915 | 500 | 420 | 450 | 1,370 | 940 | — | Open |
| *Residual amperes current, Ply. | — | — | — | 1,300 | 1,350 | — | — | — | 700 | 3,000 | — | 2,600 | 4,500 | — | 2,600 |
| †Pos. sequence kv., Ply. | — | — | — | — | — | — | — | — | 115 | 87 | 98 | 76 | 95 | — | 115 |
| Clearing time, Con. (cycles) | — | 10 | 102 | Open | Open | 69 | Open | 45 | 107 | 71 | 37 | 11 | 12 | ‡40–50 | Open |
| Clearing time, Ply. (cycles) | — | 62 | 20 | 18 | 16 | 20 | 35 | 31 | 35 | 33 | 55 | 8 | 15 | [illegible] | 8 |
| Load, Conowingo | 168 | 112 | 140 | 30 | 0 | 66 | 0 | 263 | 170 | 92 | 150 | 235 | 145 | 165 | 35 |
| Load, P. E. steam gen. | 34 | 46 | 220 | 225 | 211 | 349 | 226 | 159 | 258 | 145 | 323 | 89 | 248 | 241 | 163 |
| Load, P. E. system | 202 | 158 | 360 | 252 | 207 | 423 | 250 | 392 | 390 | 223 | 473 | 319 | 345 | 396 | 207 |
| 220-kv. system set-up | Solid | Solid | Solid | Solid | Solid | Solid | Solid | Solid | Split | Solid | Solid | Solid | Solid | Solid | Solid |
| Conowingo stability | Unstable | Unstable | Unstable | OK | Off | OK | Off | OK | OK | OK | OK | OK | OK | Unstable | OK |
| Conowingo power swings after fault cleared | — | — | — | — | — | — | — | ‡200–325 | 75–100 | 70–110 | 130–155 | 164–292 | 114–185 | +313–313 | 31–38 |

*Measured in faulted line. †Equivalent line to neutral voltage; normal value 127 kv. ‡Estimated. All load and power values given in megawatts.

for such high voltage service. The generators were built with as low transient reactance as possible consistent with reasonable cost and efficiency. To obtain low reactance in these machines was rather difficult because of their slow speed (80.8 r.p.m.) but it was possible to reduce the transient reactance to about 29 per cent and still have a fairly well-balanced design. Transformer reactance was kept as low as was possible with safety, and this resulted in a value of about 9 per cent. The Plymouth Meeting transformers were so arranged that the synchronous condensers connected to their tertiary windings would be closely coupled to the 220-kv. system in order to secure maximum benefit from them in maintaining stability.

One 30,000-kva. condenser is provided for each of the three transformers at Plymouth Meeting, and these condensers have rather special excitation as described in a previous publication.[5] In case of a system disturbance the exciter voltage is increased automatically at a rate of over 6,000 volts per second, and the load on each condenser increases from a normal value of 10,000 kva. to about 58,000 kva. in 0.5 sec. Two additional condensers with automatic high speed excitation are installed at Westmoreland substation and the 60-cycle motors of many frequency converters on other parts of the Philadelphia Electric system are used as condensers, all of these being provided with automatic voltage regulators. Conowingo generators have special high speed excitation, designed to prevent a drop of more than 2 per cent in their induced voltage when full-load lagging reactive kva. is applied suddenly while carrying full rated load at unity power factor.

### INSTABILITY EXPERIENCED WITH INITIAL OPERATION

During the first year (1928) three faults, all caused by lightning flashovers, occurred on the Plymouth Meeting-Conowingo lines; each fault involved two phases instead of only one as expected and assumed as the basis for design. Conowingo became unstable for each of these faults and also on one other occasion when a severe disturbance occurred due to an oil fire and explosion along the Chester-Schuylkill lines of the 66-kv. system. (See Table I.)

This experience during the first year, when every fault on the Plymouth Meeting-Conowingo line caused instability, naturally was very alarming and extensive study was given to determine the cause of the trouble, and to ascertain what could be done to correct the condition. The study was handicapped at first by a lack of definite records of the time and sequence of events. Some doubt existed regarding the performance of relays, switching time, and operation of the governors. In addition, all four cases of instability occurred before the installation of synchronous condensers was complete and before the high speed excitation system was working satisfactorily.

While practically no interruption of service to customers resulted from these disturbances, it was realized that something must be done immediately to increase the reliability of Conowingo station, therefore a number of temporary measures were adopted pending the outcome of further study and experience.

It was evident that most trouble was likely to occur during lightning storms; also that service to the customer could be maintained by providing sufficient steam reserve. Arrangements were made therefore with station attendants and line patrolmen to watch for electric storms, and to report their appearance to the system load dispatcher; the load on Conowingo then could be reduced and the steam reserve built up. A practise also was adopted of operating the 220-kv. system split so that Conowingo would operate in two separate sections during storms if four or more generators were running. While this meant the certain loss of half the station with a fault on either line, it greatly reduced the chance of losing the entire station. Use of this storm set-up was discontinued in 1931 when changes had been made in some of the equipment so that it no longer was required.

## SPECIAL TESTS

While relief was obtained by the temporary measures just outlined, a series of tests was made to check practically all uncertain factors affecting the performance of the system. The most comprehensive of the tests was a series of single-phase and two-phase faults made at various locations on the Plymouth Meeting-Conowingo lines, records being obtained on all parts of the system by observers and special recording equipment. These tests were made with most of the synchronous equipment and lines in service, but without load because of the danger of disturbing customers. A total of 29 oscillograph elements were used in the test, connections to these being shifted to measure various quantities for the different faults. High speed moving pictures were taken of all faults and of the governors on several generators.

Principal conclusions from this series of tests were as follows:

1. Relay operations were correct and all faults were cleared with more than sufficient margin to prevent the disconnection of any equipment other than the line faulted.
2. Over-all clearing time for faults including switching and relay operation was somewhat longer than expected, averaging a little over 0.5 sec. for the first switch and 1.0 sec. for the second switch.
3. No serious swinging of one Conowingo generator against another was observed.
4. No hunting of governors occurred.
5. Faults were apparently of low impedance and did not "blow" from one conductor to another.
6. The high speed excitation system was not performing as well as expected.
7. Calculated short-circuit currents were in reasonably close agreement with actual test values.

Another test which was made consisted of opening switches on the Conowingo generators while the machines were carrying load. This was done to ascertain the speed characteristics and governor response of these units as well as furnish a service check of the overspeed and overvoltage protection. This test showed that the speed increased so rapidly when full load was dropped that some of the units advanced 180 deg. ahead of the system in less than 0.3 sec. This naturally explains how the plant can get out of synchronism so quickly when the electrical output is reduced seriously by the voltage reduction caused by a severe system fault.

Special tests were made also on the synchronous condensers under load conditions to check the operation of the high speed excitation system and to determine the best adjustments; after some changes had been made, performance was brought up to expectations. The test on the Plymouth Meeting condenser is described in a previous publication.[5] Still another test was the measurement of zero sequence reactance of the Conowingo lines. This consituted one of the uncertain factors assumed in the calculations; the test showed that the measured value was in close agreement with that used in the calculations.

Supplementing the information obtained in the special tests, complete records and reports of each system disturbance are obtained by the following means:

### 1. Automatic Oscillographs

As soon as obtainable, automatic oscillographs were installed permanently at Conowingo and at Plymouth Meeting, a six-element instrument at the former station and a seven-element unit at the latter; most of the time a second six-element oscillograph has been in use at Plymouth Meeting. A four-element Hall recorder is installed at Westmoreland. To obtain records of field experience and special information additional oscillographs

Table II—Faults on Plymouth Meeting-Siegfried and Plymouth Meeting-Roseland 220-Kv. Lines

| Year | 1928 | | 1929 | 1930 | | | 1931 | |
|---|---|---|---|---|---|---|---|---|
| Date | 7–12 | 7–24 | 8–13 | 6–26 | 7–9 | 12–10 | 7–14 | 9–6 |
| Time | 5:15 p.m. | 8:02 a.m. | 11:37 a.m. | 7:12 p.m. | 10:17 p.m. | 4:17 p.m. | 6:14 p.m. | 4:28 a.m. |
| Line | Sieg. | Sieg. | Sieg. | Sieg. | Sieg. | Rose. | Rose. | Sieg. |
| Cause | Ltng. | Ltng. | Ltng. | Ltng. | Ltng. | Foreign object | Ltng. | Switch failure |
| No. phases faulted | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Miles from Ply. Mtg | 40 | 15 | 35 | 17 | 14 | 65 | — | 0 |
| *Residual amperes, Ply | 1,000 | 1,440 | 1,070 | 1,840 | 1,750 | 600 + | 2,000 | — |
| †Pos. sequence kv., Plymouth | — | — | — | 92 | 98 | — | 115 | — |
| Clearing time, Ply. (cycles) | 65 | 65 | 92 | 30 | 35 | 71 | 8 | 150 |
| Load, Conowingo | 208 | 218 | 41 | 120 | 25 | 0 | 172 | 28 |
| Load, P. E. steam gen | 65 | 173 | 341 | 221 | 262 | 434 | 150 | 134 |
| Load, P. E. system | 263 | 395 | 349 | 369 | 323 | 453 | 312 | 179 |
| 220-kv. system set-up | Solid | Solid | Solid | Split | Solid | Solid | Solid | Solid |
| Conowingo stability | OK | OK | OK | OK | OK | Off | OK | Tripped |
| Conowingo power swings after fault cleared | — | — | None | 95–142 | 20–25 | Off | 166–181 | — |

*Measured in faulted line. †Equivalent line to neutral voltage; normal value 127 kv. All load and power values given in megawatts.

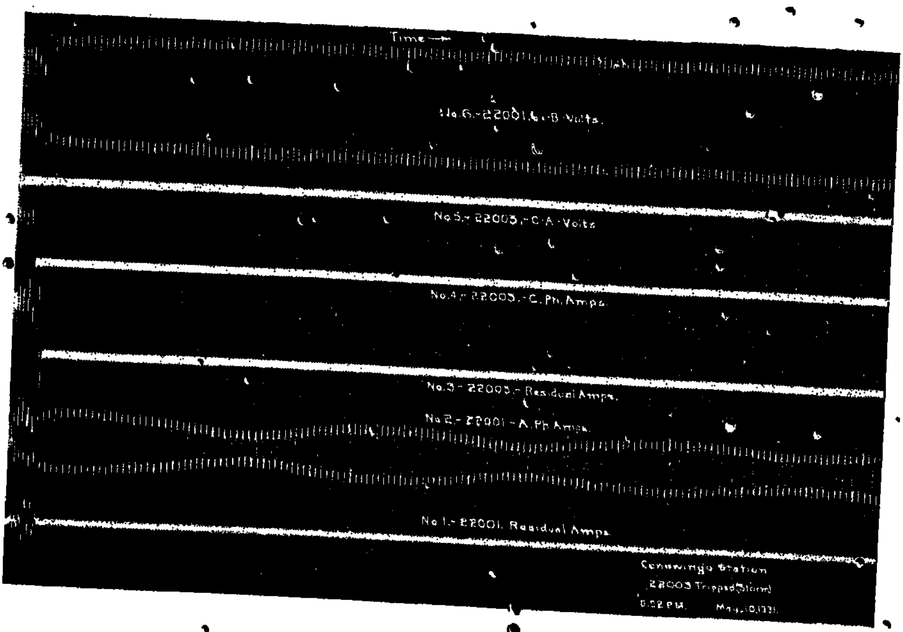

Fig. 4. Oscillogram of system disturbance May 10, 1931, showing operation of high-speed circuit breakers. Stability maintained through a two-phase fault on Conowingo line

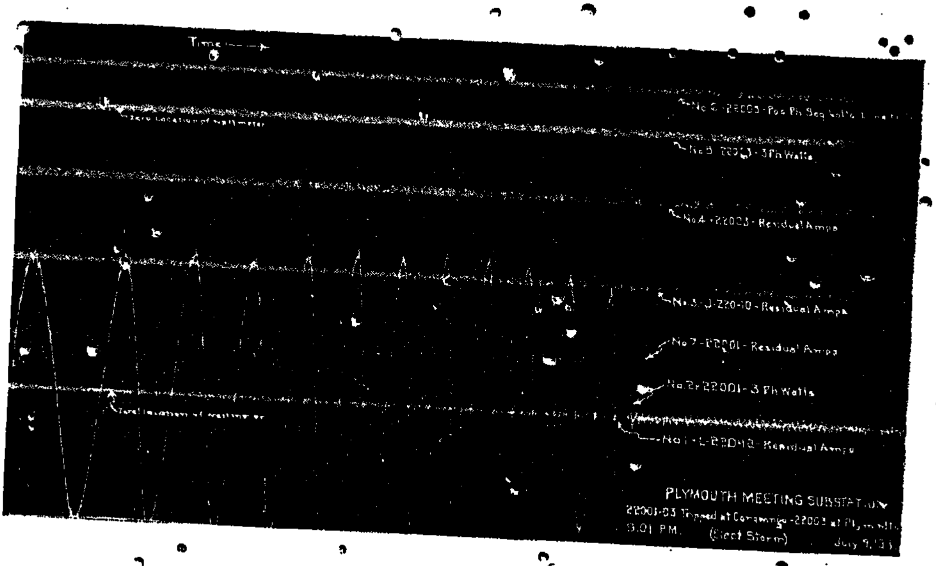

Fig. 5. Oscillogram of system disturbance July 9, 1931. Instability resulting from three-phase fault on Conowingo line

and recorders have been installed temporarily from time to time. These oscillographs record residual current in all lines, power in each of the Plymouth Meeting-Conowingo lines, positive sequence voltage, and selected line currents and voltages. They are started automatically with station residual current, but arrangements are being made to start them also with line current, since three-phase faults recently experienced have had insufficient residual current for this purpose.

### 2. Reports from Station Operators

Most of the relays are equipped with operation indicators and the more important relays are connected to a drop signal system so that it is possible to see which relays operate for each disturbance. Thus usually it is possible to determine the phases which are faulted, and the general fault location. Operators are instructed to note the time of each disturbance and to make a record of all relay operations. They report also indications of maximum reading ammeters in the neutral ground connection of the high voltage transformer windings. Graphic recording meters furnish a continuous record of power, voltage, and frequency. Of course station records are kept which show the system set-up and machines in operation at all times.

### 3. Line Reports

Thorough inspection is made of the line immediately after each fault to determine the damage, location, and number of phases involved.

All available information is collected for each important disturbance and these records are analyzed to determine the cause, number of phases involved, location of fault, fault current, switching sequence, time of clearing, power swings, and other important factors. Records of all severe disturbances have been referred to the major equipment manufacturers to secure their recommendations regarding means of improvement.

In view of the experience with two-phase faults during the first year, further stability calculations were made, based upon this type of fault. These calculations showed that with solid 220-kv. bus operation and heavy load on the plant, a two-phase fault occurring near the end of the line could be expected to cause instability if cleared in approximately 0.5 sec.; however, if the fault was cleared in about 0.15 sec., the system probably would remain in synchronism. A similar study was made for two-phase faults on the Plymouth Meeting-Westmoreland lines; this showed that high speed switching was needed also on these lines.

Equipment manufacturers thought it possible to increase greatly the speed of clearing faults by means of new designs in circuit breakers and relays; and with the need for higher speed operation apparent, they immediately undertook the development of suitable equipment. Some experimental models of new relays and oil circuit breakers accordingly were tested at Plymouth Meeting by means of short circuits on the 220-kv. system. These tests were successful in showing that interrupting time of the order of 0.14 sec. was possible.[6,7]

## EQUIPMENT CHANGES TO INCREASE STABILITY

As a result of the various studies and tests described together with normal development of the system, the following permanent improvements were decided upon:

1. New high speed circuit breakers were provided at Plymouth Meeting and Westmoreland for normal operation on all 220- and 66-kv. aerial lines.
2. The 220-kv. line circuit breakers at Conowingo were rebuilt so that high speed operation was obtained.
3. Relay system was revised and new high speed relays installed on all lines to reduce operating time to about one cycle.
4. A third step-down transformer was installed at Plymouth Meeting.
5. A third 66-kv. line was added between Plymouth Meeting and Westmoreland.
6. The 66-kv. system was split into three separate sections at Plymouth Meeting and Westmoreland.
7. Insulation of the 220-kv. lines was increased from 14 to 16 units for suspension insulators, and from 16 to 18 units for strain insulators.

## OPERATING EXPERIENCES SUMMARIZED

General experience with Conowingo since 1928 has been quite satisfactory. Many disturbances have occurred due to faults on practically all parts of the system, but since the first year of operation when four cases of instability occurred, various steps have been taken to improve operation. As a result there has been only one additional case wherein Conowingo became unstable. The disturbances have been classified according to the location of the fault on the system and are discussed under six general headings.

*Plymouth Meeting-Conowingo line faults.* Principal

### Table III—Faults in Philadelphia Electric System 220-Kv. Transformers

| Year | 1928 | | 1929 | | 1930 | 1931 |
|---|---|---|---|---|---|---|
| Date | 4–11 | 12–22 | 12–28 | 12–28 | 5–27 | 3–28 |
| Time | 11:01 p.m. | 10:33 p.m. | 10:43 a.m. | 10:47 a.m. | 4:53 a.m. | 11:53 a.m. |
| Station | Con. | Ply. | Con. | Con. | Con. | Con. |
| Cause | Bushing flashover | Winding failure | Winding failure | Energize faulty trans.† | Winding failure | Winding failure |
| No. phases faulted | 1 | 1 | 1 | 1 | 1 | 1 |
| †Pos. sequence kv., Ply | — | — | 92 | — | 90 | 96 |
| Clearing time, 220-kv. (cycles) | — | 26 | 70 | 36 | 40 | 45 |
| Load, Conowingo | 147 | 90 | 262 | 186 | 186 | 258 |
| Load, P. E. system gen | 119 | 230 | 198 | 256 | 68 | 147 |
| Load, P. E. system | 222 | 300 | 419 | 419 | 232 | 383 |
| 220-kv. system set-up | Solid | Solid | Solid | Solid | Solid | Solid |
| Conowingo load dropped | 71 | 0 | 64 | 0 | 33 | 36 |
| Conowingo stability | OK | OK | OK | OK | OK | OK |
| Conowingo power swings after fault cleared | — | — | 180–250 | 60–300 | 90–270 | 120–342 |

†Equivalent line to neutral voltage; normal value 127 kv. All load and power values given in megawatts.

data for each fault experienced on the Plymouth Meeting-Conowingo lines are shown in Table I. Some of the information is only approximate but for the sake of completeness it has been included wherever possible.

Fifteen faults including nine single-phase, five two-phase, and one three-phase have been recorded on the Conowingo lines. Instability resulted from the three-phase fault and from three of the two-phase faults which occurred in 1928 before the high speed circuit breakers were in service.

In 1929 no faults occurred while the station was carrying any great amount of load; so there was no real test of stability during the year. At the beginning of 1930, however, there was a rather unusual experience of an electric storm in winter. This caused a lightning flashover of one phase on one Conowingo line while the station was operating with solid 220-kv. bus and loaded to maximum capacity. Very heavy swinging occurred but stability was maintained. An oscillograph record of this disturbance as obtained at Conowingo may be seen in Fig. 3. Clearing time for this fault at Plymouth Meeting is shown by the length of the first step in the residual current record and the clearing time at Conowingo by the total length of the residual current record. Allowance must be made for the starting time of the oscillograph, which in this case was about eight cycles. The record of voltage on the faulted line is interrupted some time before the fault was cleared, due to the operation of an auxiliary switch on the breaker mechanism. The record of current in one phase of the unfaulted line (No. 2 vibrator) shows the surging after the fault was cleared.

The new equipment for high speed clearing of faults was in service in 1931 and showed its value for the first fault of the year which was a flashover of two phases while Conowingo was almost fully loaded. The fault was cleared from Plymouth Meeting in about eight cycles or 0.133 sec. and from Conowingo in 11 cycles as shown by the oscillograph record from Conowingo (see Fig. 4). Time lost between the beginning of the fault and the first visible record is approximately 3 cycles. Rather heavy surging occurred after the fault, but stability was maintained.

The worst disturbance and the only one which has caused instability since the first year's operation was the three-phase lightning flashover of 1931. The plant was carrying 165,000 kw. and the fault was not cleared for almost a full second because there was practically no ground current, and the only high speed relays in service were ground relays. Since this experience, high speed balanced protection has been added to take care of such conditions. Due to the relatively small ground current, the automatic oscillographs did not start until the circuit breaker had interrupted the fault. No definite record was obtained of the clearing time. The record which was obtained (Fig. 5) is of interest, however, since it shows the power swings of the station out of synchronism with the system. The unfaulted line finally tripped as shown by cessation of power swings. The crest of the power swing was used to check stability calculations by comparison with the crest of the power angle diagram calculated for this condition. These check to within a few per cent, which seems to indicate that the assumptions used in the stability calculations are reasonably satisfactory.

*Faults on the 220-kv. Pennsylvania-New Jersey interconnection.* Faults experienced on the 220-kv. interconnection lines running from Plymouth Meeting to Siegfried and Roseland are listed in Table II. So far as known all eight faults were single-phase; while most of these were of relatively long duration, none seriously affected stability. It should be noted, however, that the load on these lines is usually rather small, seldom exceeding 50,000 kw. The Roseland line was not placed into service until near the end of 1930, so that on this line comparatively little experience is available. It was equipped initially with high speed circuit breakers, but the first fault was slow in clearing because it was so near the Roseland end of the line that it was outside the zone of operation of the high speed relays. The next fault which was probably much closer to Plymouth Meeting was cleared in 8 cycles. The last disturbance on the Siegfried line was rather unusual, being caused by failure of the circuit breaker at Plymouth Meeting when the line was being opened. Some material jammed the oil valve connecting one of the switch tanks to the oil system, so that before the breaker was opened most of the oil had drained out without being noticed. Naturally flashover to ground occurred inside the tank. This was equivalent to a 220-kv. bus fault at Plymouth Meeting and was cleared as expected by trip-out of all 220-kv. feeds into that station. This involved considerable time delay, but the system was not seriously disturbed probably because at the time Conowingo was carrying but very little load.

*220-Kv. transformer faults.* Several failures have occurred in the 220-kv. transformers at Plymouth Meeting and Conowingo as shown in Table III. Most of these failures have occurred in the windings, each failure involving only one phase. Synchronism has been maintained through all of these faults, although they were not cleared very quickly and in some cases the station was carrying full load.

*Plymouth Meeting-Westmoreland line faults.* Faults experienced on the Plymouth Meeting-Westmoreland 66-kv. lines are shown by Table IV. Since these lines carry most of the Conowingo output and have considerably higher percentage of reactance than the Plymouth Meeting-Conowingo lines, the matter of line faults is rather serious. Fortunately very few faults occurred there during the first three years when only two lines were in use. The first fault caused both lines to trip apparently due to the relay settings being too low. The next fault occurred when there was but little load on Conowingo, and synchronism was maintained. The remaining faults all occurred in 1931 after the third line had been added and after the new high speed switches and relays were in service. Most of these faults were unusually severe involving two and three phases, and in one case two lines; but they were cleared quickly and stability was maintained in every case.

*Faults on interconnected system.* Faults occur frequently on the Pennsylvania Power and Light Company system, particularly on the Wallenpaupack-Siegfried line.[8,9] However, none of these faults has caused instability at Conowingo even though a three-phase short circuit occurred at Siegfried while Conowingo was carrying full load. This fault lasted for about 52 cycles, reducing the positive sequence voltage at Plymouth Meeting to 76 kv. or about 60 per cent of normal. The maximum swinging of Conowingo power after the disturbance was from about 174 to 334 megawatts. This disturbance was far more severe than generally experienced with faults on the Pennsylvania Power and Light system which usually cause no power surges at Conowingo.

*Faults on Philadelphia Electric main system.* Faults on the Philadelphia Electric 66-kv. system excluding the Plymouth Meeting-Westmoreland lines usually cause but little disturbance at Conowingo. A large part of the 66-kv. system consists of single-conductor underground cable so that most of the faults involve only one phase. These faults sometimes last for more than one second, but there is seldom any trouble except burning of the cable and an occasional tripping of some synchronous motors and converters. A system of pilot wire protection is being installed to reduce the clearing time for cable faults.

One case involving a two- or three-phase fault on the Schuylkill-Chester 66-kv. aerial line in 1928 caused loss of synchronism in some of the machines at Conowingo as described previously. Other cases of two- or three-phase faults have developed on the 66-kv. system since the first year, but none of these has caused instability.

## CONCLUSIONS

Based upon experiences with Conowingo hydroelectric station and with other parts of the Philadelphia Electric Company system described in this article, the following conclusions may be stated:

1. Faults on parts of the system other than the main lines from Conowingo have but little effect upon stability of that station.
2. Single-phase faults on the main lines from Conowingo have no serious effect on stability, but two- or three-phase faults under heavy load conditions are liable to cause instability unless cleared very quickly; faults of this type are likely to occur on the high voltage system.
3. Installation of high speed relays and circuit breakers on the high voltage system has insured the rapid clearing of faults; this practically eliminates the danger of instability except possibly for three-phase faults.
4. System stability may be calculated with sufficient accuracy for all practical purposes, and such studies are essential in system design.

**Table IV—Faults on Plymouth Meeting-Westmoreland 66-Kv. Lines**

| Year | 1928 | | 1931 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | 6–5 | 7–1 | 5–16 | 7–14 | 7–14 | 7–14 | 7–14 | 7–14 | 7–14 | 7–14 | 8–10 |
| Time | 10:18 p.m. | 7:28 a.m. | 3:53 p.m. | 7:47 p.m. | 7:49 p.m. | 7:52 p.m. | 7:57 p.m. | 9:03 p.m. | 9:14 p.m. | 10:06 p.m. | 5:58 p.m. |
| Cause | Ltng. | Short circuit | Short circuit | Ltng. | Ltng. | Ltng. | Ltng. | Ltng. | Ltng. | Ltng. | Ltng. |
| No. phases faulted | 2 | 3 | 1 | 3 | 3 | ‡3 | 1 or 2 | 2 | 3 | 3 | 1 |
| Miles from Ply. Mtg. | 5 | 0 | 0 | 4 | 2 | 3 | 1 | 3 | 1 | 1 | 1 |
| †Pos. sequence kv., Ply | — | — | 125 | 117 | 92 | — | — | — | — | — | 110 |
| *Residual amperes, Ply | — | — | Open | — | 750 | — | — | — | — | — | 7,620 |
| Clearing time, Ply. (cycles) | — | Open | Open | 18 + | 17 + | — | 13 | — | — | 7 | 12 |
| Clearing time, Westmld. (cycles) | — | — | 16 | — | — | — | 7 | — | — | 13 | 15 |
| Load, Conowingo | 180 | 98 | 255 | 202 | 202 | 202 | 202 | 226 | 226 | 168 | 42 |
| Load, P. E. steam gen. | 55 | 35 | 47 | 186 | 186 | 186 | 186 | 255 | 255 | 150 | 335 |
| Load, P. E. system | 252 | 116 | 294 | 388 | 388 | 388 | 388 | 473 | 473 | 322 | 379 |
| 66-kv. system set-up | Solid | Solid | Solid | Split | Split | Split | Split | Split | Split | Split | Split |
| Conowingo stability | Tripped | OK | OK | OK | OK | OK | OK | OK | OK | OK | OK |
| Conowingo power swings after fault cleared | — | — | 235–290 | 165–280 | 140–322 | — | — | — | — | — | None |

*Measured in faulted line. †Equivalent line to neutral voltage; normal value 127 kv. ‡Double line fault. All load and power values in megawatts.

5. Much credit is due the manufacturers for the development of practical methods of studying stability, and for the production of equipment for improving operating stability.

6. Short-circuit tests on the system and special tests on equipment such as that used to obtain high speed excitation fully justify the expense incurred.

7. Permanently installed automatic oscillographs are desirable for: (a) investigating and analyzing conditions when instability occurs; (b) checking calculations of stability limits; and (c) checking relay operations.

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# Automatic Combustion Control

**Equipment for the automatic control of combustion in modern steam plants is installed as much to achieve operating speed and simplicity as it is to effect operating economy. Fundamentals of typical systems are outlined here.**

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THE SUCCESSFUL application of automatic devices to power plant combustion control has been very largely a development of the past ten years. During this period confidence in automatic operation was greatly strengthened by its success in other fields, particularly in that of electric substations and hydroelectric generating stations. Moreover, because of the ever increasing urge for higher efficiencies and lower fuel and labor costs, its development and application has had whole-hearted approval and assistance of engineers and operators.

Earliest attempts at automatic control employed damper regulators actuated by steam pressure. Then, with the development of automatic stokers and forced draft, regulators were applied to blower engines and to the maintenance of balanced or nearly balanced furnace draft. This early apparatus was very crude in its mechanical features, and had the bad habit of being either all "on" or all "off," thus producing a steam pressure chart having frequent and wide fluctuations. The next step in the development was a departure from these unreliable automatic devices in the application of permanent instruments to indicate draft and rate of coal feed, together with better facilities for hand control. Where hand control of the entire plant was centralized, improvement was realized in the uniform loading of the various boilers and in the much closer regulation of steam pressure.

Development of a modern boiler plant necessitates the consideration of large units where, in many cases, the auxiliary equipment may be located a hundred feet or more from the control point. Also, large stokers may be used requiring varying air pressure in their different sections, or gas, oil, or pulverized fuel may be selected and for which efficient operation requires closely coordinated regulation of fuel and air. The necessary complement of gages and meters for a single boiler has been very greatly increased while economic necessity has reduced the number of men. The unit cost of labor and fuel has trebled in the last thirty years and consequently comparatively small savings in these items may justify the expenditure of material sums for new equipment to produce such results.

Another point is the fact that, because of the usually small amount of steam storage, fluctuations in station load almost immediately are reflected in steam demand. If maximum efficiency is to be maintained consistently these fluctuations in demand must be met by corresponding changes in fuel and air supply. When a multiplicity of boilers supply the same steam system, any change in station load normally should be properly

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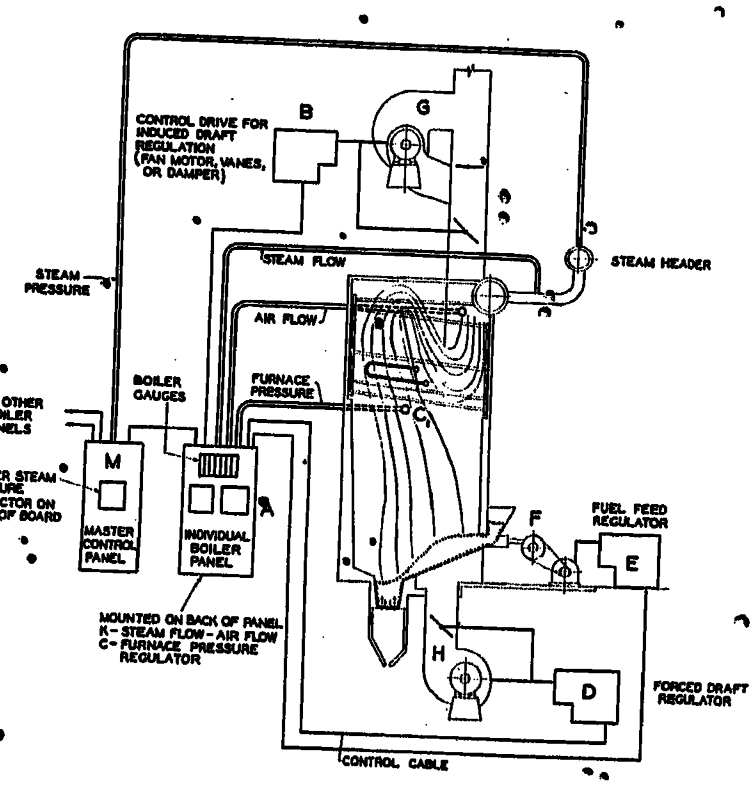
divided among all boilers. If the operating force is sufficient in numbers, highly skilled, and supplied with adequate instruments, results can be obtained with a well planned manual control which compare favorably with the best automatic control. However, the automatic control is ever alert to perform its functions. Its chief advantage lies in its ability to act simultaneously throughout the plant, thus permitting a reduction in the required number of skilled operators.



Bailey combustion control system

Large, modern boiler installations commonly are equipped with push-button type of remote control which represents probably the most easily and quickly manipulated type of manually operated equipment. The cost of such a system represents a large portion of the cost of a complete automatic control system, and it may be incorporated as a part thereof.

## ADAPTING THE CONTROL TO THE INSTALLATION

While control systems can be adapted to most any type of boiler auxiliary equipment, the smoothness of operation often is complicated by the inherent characteristics of the apparatus controlled. The ideal combination of control and auxiliary equipment is one which, by delivering to the furnace a proportionately changed amount of fuel and air, gives immediate response to a change in demand. Some types of equipment inherently are capable of approaching this ideal more closely than others and an understanding of such characteristics will be helpful in an understanding of what may be accomplished with automatic control.

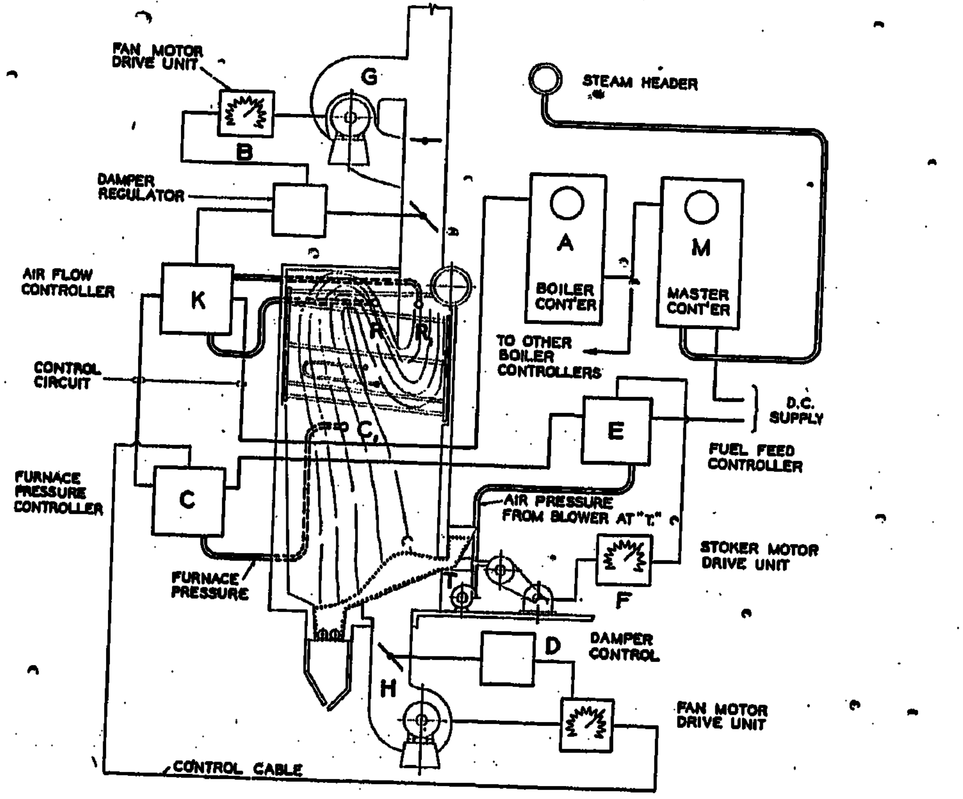
*Air Supply.* Air supply control usually is actuated by draft at the boiler outlet. Some types of draft-producing equipment can be controlled for smooth changes in small increments; others operate with large increments. Among the types of draft equipment producing smooth changes are:

1. Chimney draft—damper control.
2. Steam driven fans—driver control.
3. D-c. motor driven fans—driver control.
4. Wound rotor a-c. motor driven fans—driver control.
5. Single speed a-c. motor driven fans—damper control.

Among the types of draft equipment producing abrupt changes of relatively large magnitude are:

1. Multi-speed induction motor driven fans—driver control.
2. Multi-speed induction motor driven fans—driver and damper control.
3. Multi-speed induction motor driven fans—driver and vane control.

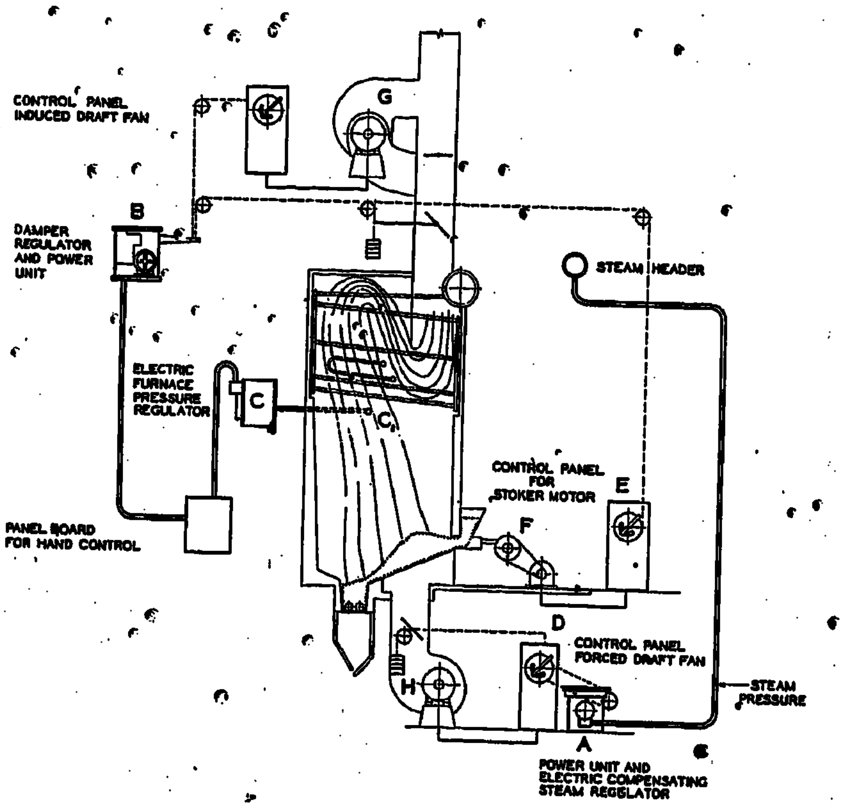
Large, modern boiler installations employing long stokers commonly require a supply of air at several different points at different pressures. This condition makes necessary the provision of several windbox pressure controllers which may be adjusted either for a constant ratio or for varying ratios for the different sections of the stoker as conditions may demand. Similarly, pulverized fuel installations may require individual regulation of the primary, secondary, and tertiary air pressures.



Leeds and Northrup combustion control system

In most systems of control involving the supply of air under pressure for combustion it is necessary to provide an auxiliary control to prevent the occurrence of a furnace pressure above atmosphere. This control is actuated by furnace draft and usually functions as an emergency or readjustment mechanism on the forced draft fan.

Many different types of automatic control are available for application to the different systems used for producing draft or air supply. For example: in natural draft installations the automatic control is usually applied to the stack damper; for variable speed motors and steam turbines the speed of the driver only is automatically controlled; in some pulverized fuel systems employing a unit system, it is necessary to introduce a time lag in the air supply equipment to allow for the interval between the increase or decrease in the coal supply to the mill and the time when this change in supply reaches the furnace.


CONTROL PANEL INDUCED DRAFT FAN
G
B
DAMPER REGULATOR AND POWER UNIT
STEAM HEADER
ELECTRIC FURNACE PRESSURE REGULATOR
C
C
CONTROL PANEL FOR STOKER MOTOR
E
F
PANEL BOARD FOR HAND CONTROL
D
CONTROL PANEL FORCED DRAFT FAN
H
STEAM PRESSURE
A
POWER UNIT AND ELECTRIC COMPENSATING STEAM REGULATOR

Enco combustion control system

*Air Measurement.* In a few cases it is possible to measure the air supply by means of an orifice or some other metering device installed in the air supply line. However, and usually because appreciable quantities of air enter through openings in the furnace setting, it is necessary to base the air control on the flow of the gases of combustion rather than upon the air supply. The medium most often used for this control is the pressure drop through a bank of boiler tubes. When the tubes are reasonably clean this method of air control is sufficiently accurate for all practical purposes. When the tube bank becomes partially covered with slag, manual readjustment of the air supply controller is necessary unless an additional control connection is made with some form of $CO_2$ meter to provide automatic readjustment.

*Fuel Supply.* Types of fuel supply equipment have a very marked influence on the quickness of response to a change in load and on the effect of large abrupt changes in draft on combustion conditions. The following types of supply equipment afford immediate response:

1. Gas.
2. Oil.
3. Pulverized coal—bin and feeder system.
4. Stokers carrying a heavy fuel bed.

The following types have a slow response (from one to fifteen minutes):

1. Pulverized coal—unit system.
2. Stokers carrying a light fuel bed.

All types of fuel supply are adversely affected by large, abrupt changes in air supply; the disturbance in all cases being more marked with water-cooled furnaces than with refractory furnaces. The effect on some of the more widely used systems is as follows:

| Conditions | Effect |
|---|---|
| 1. Stokers with deep fuel bed | Smoke and temporary loss in efficiency |
| 2. Stokers with light fuel bed | Blowing bare spots on grates, loss in efficiency and capacity over a considerable period |
| 3. Pulverized coal—bin and feeder system | Possible loss of ignition |
| 4. Oil and gas | Possible loss of ignition |
| 5. Pulverized coal—unit system | Probable loss of ignition |

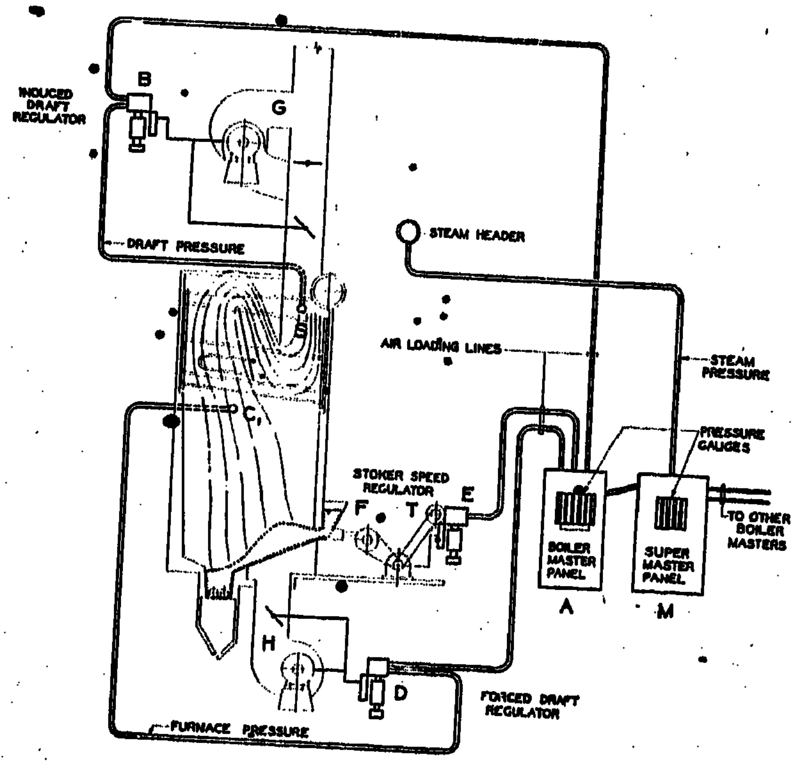
*Fuel Measurement.* Where coal is the fuel, the measurement of supply commonly is derived from the revolutions of the fuel feeding mechanism, each revolution of which is assumed to inject a given quantity of combustible material into the furnace. Unfortunately, however, coal is one of those natural products subject to wide variation in physical and chemical characteristics which variations are reflected in the fuel value per unit of volume. Consequently, correct ratio of fuel and air can be maintained only by occasional manual readjustment of the coal feeding mechanism or by an automatic air adjustment mechanism actuated by a $CO_2$ meter or a steam-flow air-flow meter.

*Sequence Interlocking of Control.* In nearly all large modern boiler installations it is necessary to provide sequence interlocking between certain of the control points. For example: it is usually necessary that a shut-down of the induced draft fan simultaneously interrupts the coal feed and air supply, and that the coal feeding mechanism will not overtravel beyond the ability of the induced draft fan to take away the products of combustion. In many installations firing pulverized fuel there is a low limit of coal and air feed below which combustion becomes unstable and the fire may blow out.

Wherever automatic combustion control is applied, each boiler unit is provided with a simple and ready means for changing from automatic to hand control as may be necessary under such emergency conditions as the whole or partial interruption of the supply of coal, air, or feed water to an individual boiler.

*Control-Power Supply.* To insure continuity in the operation of the control system, the supply of the medium through which the control impulses are carried to the various regulators must be safeguarded positively by the provision of two or more independent sources of supply and a ready means of changing from one source to another. Pneumatic and hydraulic systems originally were employed, but with the advent of electrically operated remote control, electricity has been adopted by many manufacturers as the medium for automatic control. These electrical control drives are designed to use either alternating or direct current at any voltage from 110 to 250.

*Systems.* Probably no two power plants ever built were exactly alike. Comparison of any one with another as regards the detailed requirements of an automatic combustion control system reveals a surprising lack of standardization. Naturally the same is true of the control systems employed, and therefore only a generalized performance specification together with diagrams of several typical systems will be given here.



Smoot combustion control system

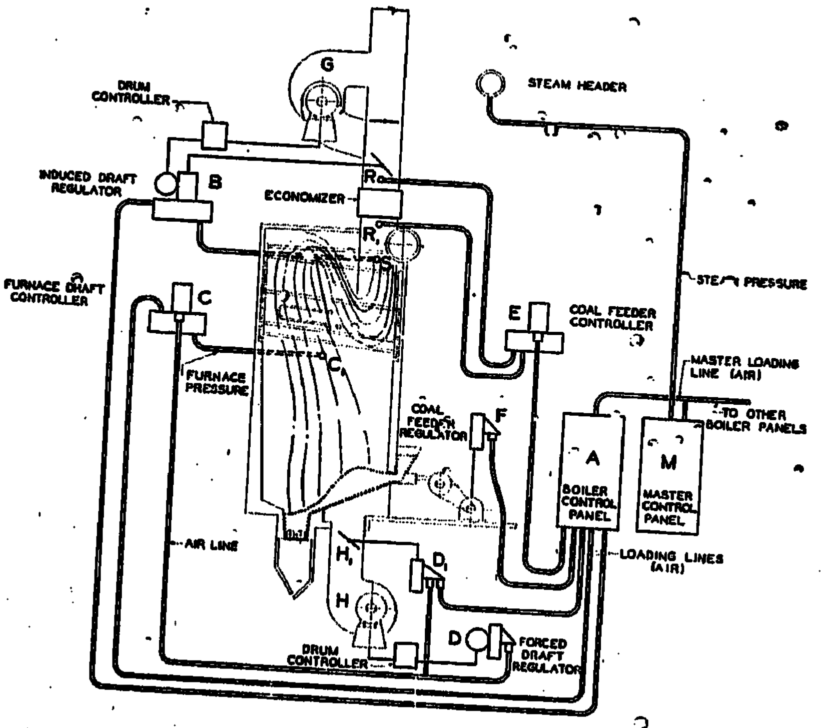
In all systems impulses actuated by variations in steam pressure are transmitted simultaneously to the various individual boiler control panels from which radiate the controls of fuel and draft. The control performance in general is as follows:

1. An increase in plant load causes an increased demand for steam and therefore a drop in steam pressure.

2. Changes in steam pressure are converted into impulses which actuate a regulating device controlling in proportion to the load the rate of fuel and air supply to the boiler. Forces or impulses which are not linear are adjusted in the regulator.

3. Since the regulator can control only mechanical forces which under normal conditions will supply the correct amount of fuel and air, variations from the assumed normal conditions must be compensated for by changing the relation between these mechanical forces which supply either fuel or air so that the correct amount of each is supplied to the boiler. A furnace pressure regulator and a $CO_2$ recorder will detect and make adjustments for variations from normal conditions. These variations are caused by slagging, damp coal, or an irregular supply of coal.

4. Controls can be set so that certain boilers maintain a constant output while other boilers take the variations, and can be provided with maximum and minimum stops to limit the range of output.



Hagan combustion control system

5. Control of any or all functions can be accomplished separately or in groups and either directly or indirectly as required by individual conditions.

6. Some of the available systems are provided with audible and selective visual signals to indicate equipment failure.

## CONCLUSIONS

The question as to what financial return may be expected from an investment in automatic combustion control often is asked. The answer is infinitely more involved than the question. Savings in operating expense as high as 4 per cent have been reported. Rarely, however, has it been found practicable to make comparative efficiency tests on the same installation, operating with and without automatic control, to determine definitely the annual saving in operating expense.

As a rule, automatic control seldom is installed solely on the basis of a direct saving in operating expense. In fact its installation often is based mainly upon resultant operating advantages otherwise difficult or even impossible of accomplishment. Among the more important of these advantages are:

The uniform loading of all boiler units.

Instant response to changes in load.

The supply of fuel and air in correct proportions at all times.

A ready means of providing for safety of operation through sequence interlocking of auxiliary equipment.

# Proposed Definitions of Power System Terms

DEFINITIONS of terms used in stability and interconnection studies have been developed by a special committee functioning since 1930. This subject committee was organized at that time under the auspices of the subcommittee on interconnection and stability factors of the committee on power transmission and distribution, to develop some definitions of terms used in stability studies. Later in the same year, a joint interconnection committee, with F.C. Hanker, as chairman, was formed with representatives from the committees on power generation, protective devices, and power transmission and distribution; and the work of the subject committee was continued under the direction of this subcommittee. Likewise, the scope of the definitions was increased to include terms used in interconnection as well as stability studies. The report of this work is submitted in five general divisions:

1. Interconnection terms
2. Stability terms
3. Active power and reactive voltampere conventions
4. Synchronous machine quantities
5. Response of excitation systems

In the preparation of this report, the subject committee reviewed the technical literature, particularly publications of the Institute, and consulted representative members of the committees of the Institute in order to obtain terms and their definitions which would be in accord with common usage and preferred practise in so far as possible. Attempt has been made to select terms which are descriptive of the subject. The general field covered by these definitions is indicated in the paragraphs following. It is hoped that all interested parties will become acquainted with these definitions and will express themselves freely on controversial points.

## INTERCONNECTION TERMS

In the symposium on interconnections presented at the A.I.E.E. summer convention in Asheville, N. C., June 1931, several interconnection terms were used for the various power quantities which may flow between interconnected power systems. It seems desirable at this time to propose definitions of these terms before too many loose expressions come into general use. In the report, therefore, definitions of terms are presented which are descriptive and cover practically the field in its entirety. The various types of active power and reactive voltamperes are defined.

## STABILITY TERMS

A number of papers with varying phraseology and a resulting confusion of terms have been presented before the Institute on the problem of stability of power systems. The subject committee has endeavored to reconcile the opinions of the several authors into a set of terms and definitions which will satisfy the requirements of power systems and the automatic devices used to control them. After consultation with several of these authors, definitions are recommended for the various stability terms.

## ACTIVE POWER AND REACTIVE POWER VOLTAMPERE CONVENTIONS

The convention of plotting active power and reactive voltampere quantities is somewhat arbitrary and does not depend upon a strict mathematical basis. The plotting of active power usually is taken as positive in the direction of power flow from a generator, but the plotting of reactive voltamperes has not been so obvious. To date, the international committee of the International Electrotechnical Commission, as well as the present subject committee have been unable to reach an agreement upon the convention to adopt. Meanwhile the subject committee presents an arbitrary choice to foster discussion with the understanding that this choice will not prejudice further action. The proposal consists of using the complex quantity $P - jQ$ to represent the active power and lagging reactive voltamperes such as supplied by an overexcited synchronous generator. There has been considerable discussion as to whether or not $P + jQ$ should be used because $R + jX$ represents an inductive reactance.

## SYNCHRONOUS MACHINE QUANTITIES

Synchronous machine quantities are used in calculations for short-circuit currents, relay settings, stability studies, and the like. Both saturated and unsaturated values of these quantities are used in practise depending upon whether currents of very high value or of normal value are involved. The reactances as well as the time constants of synchronous machines are influenced by saturation. Since, in general, saturation effects have not as yet been sufficiently investigated to determine these constants for varying degrees of saturation, definitions are presented applying to any degree of saturation, and methods of determination by test applying to as great a degree of saturation as possible. Where alternative methods of test for reactances are given, care should be exercised in choosing the method for a particular application since they are not equally applicable for all degrees of saturation. A résumé is given of the methods of

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Excerpts from "Proposed Definitions of Terms Used in Power System Studies" (No. 32M2), being the report of the subject committee on definitions, H. K. Sels, *chairman*, R. G. Lorraine, J. R. North, and C. F. Wagner, Jr., presented at the A.I.E.E. winter convention, New York, Jan. 25-29, 1932.

test for reactances, together with the degree of saturation which readily can be obtained. Attention is called to the added cost that may be necessary in making tests to obtain more accurate synchronous machine quantities for use in calculations of system operating conditions.

### RESPONSE OF EXCITATION SYSTEMS

The development of high speed excitation systems to improve the stability of power systems has created the necessity of expressing the characteristics of the exciter when used to overexcite the main machines. In the report, definitions are proposed which meet these requirements.

While many of the definitions proposed by the subject committee may be considered arbitrary, they have been considered in the best interests of the profession. General adoption of these terms and definitions will lead to a better common understanding with less possibility of confusion and controversy in legal and technical questions.

# Engineering Supersedes Tradition

**The engineer, having learned that action is best based upon the fullest and most accurate determination of facts possible, is said to be the type now needed by the world. This is the seventh article in The Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"**

By
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Detroit (Mich.)
Edison Company

MEN whose procedures have been based mostly on precedent and tradition have for many generations had the affairs of the world in their hands. We now discover that the views and methods developed by these men are inadequate in that they do not measure up to present requirements. While this condition was being reached a new group has developed which within recent years has altered greatly many of the things having to do with human life. I refer naturally to the engineers. I use the term engineer in a much broader sense than is frequently given it. To me a real engineer is a scientifically trained business man, but the scientific training is of a variety which leads him to *apply* the results obtained by scientists rather than to expand the fields of science.

This new specimen, the engineer, represents a new type of thought. He has learned that action is best based upon the fullest and most accurate determination of facts possible at the time and under the given conditions. He endeavors to hold himself clear of the influence of preconceived ideas, traditions, precedents, rules-of-thumb.

I am not able to prove that the engineer has been appointed by God to lead the world out of the situation into which it has slowly but surely brought itself. However, in studying the history of the human race, I have noticed that individuals and groups possessing particular aptitudes and/or trainings seem to appear at just about the time the world needs what they are equipped to furnish. If this be a fact, one might be justified in assuming that the recent rapid and widespread appearance and development of the engineer indicates that he is the type now needed to carry on human development or social development or culture or whatever else you choose to call it.

I am convinced of one thing: At the present minute the world is as much in need of individuals trained and willing to discover facts and to lead where such facts indicate, as it is of anything else. I am convinced also that, by training and habit of mind, the engineer is better able to undertake such a job than is any one other single group. By this I do not mean that I believe the engineer is capable of determining unaided all of the complex variety of facts that must be uncovered if we are to alter existing conditions greatly; I assume that he will have to call to his aid others skilled in special fields; but I believe he is best fitted to assemble and direct skilled fact-finding personnel and to intepret and apply the results of its work.

I am convinced also of another thing: No such radical change in the method of handling human affairs can occur overnight. Even those changes which appear to us as revolutionary in character, upon study, prove to be evolutionary. If we have now arrived at that place in our development at which we recognize the desirability of resting action on a factual basis, we are not going to jump from here to there in the twinkling of an eye. On the contrary, we are going to go our plodding way, experimenting, arguing, discussing, and more or less applying and accomplishing, until years or generations hence our successors will be controlling the affairs of humanity by this more rational method.

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**Editor's note:** Pursuant to the invitation of The Engineering Foundation, the editors will be happy to receive comments, suggestions, criticisms, or discussions pertaining to this or other articles in this series.

# A Self Stabilizing D-C. Welding Generator

By
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**This new machine needs no external reactor, but employs a special field winding to compensate for resistance fluctuations in the welding circuit; it is completely self-contained and is self-excited. Provision is made for obtaining fine adjustments of current by simply shifting the brushes.**

RAPID EXPANSION of arc welding in recent years has served in an ever increasing degree to focus attention upon the design and operating characteristics of arc welding generating equipments. Up until a few years ago the d-c. arc welding circuit invariably constituted a welding *system* rather than a welding *generator*. This applies even to the variable-voltage individual-operator sets as well as to the constant-potential multiple-operator equipments. Generally speaking, the so-called arc welding generator does not possess all of the characteristics required for arc welding and to compensate for this, external auxiliary devices of one kind or another are resorted to. The generator described in this article is designed to have inherently all of the characteristics required for arc welding without the assistance of any external auxiliary apparatus whatever, and therefore is in every respect an *arc welding generator*.

## RESISTANCE CHARACTERISTICS OF ARC WELDING CIRCUIT

It is well known that the negative resistance characteristic of the arc makes it inherently unstable when operating from a constant potential circuit. To overcome this instability, the circuit must have a drooping volt-ampere characteristic; that is, the voltage must decrease with increasing current. Therefore individual-operator welding generators are designed to have a drooping volt-ampere curve. It is well known also, however, that when welding with a mild steel electrode, either bare or lightly flux-coated, the arc voltage drops to zero at more or less regular intervals whenever a drop of molten metal goes across the arc.

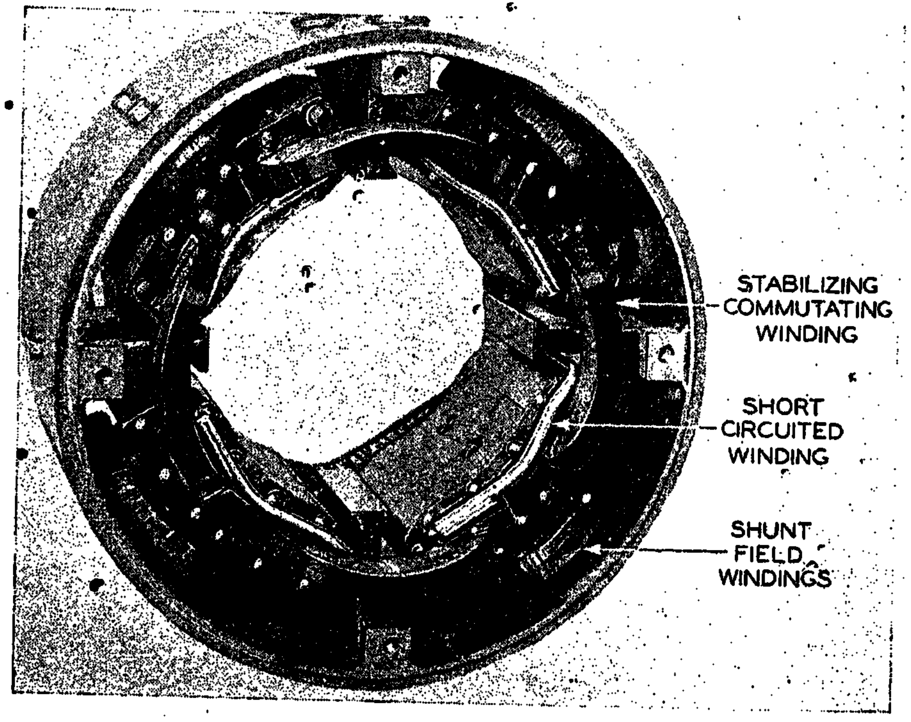

Fig. 1. Complete stator of self-stabilized arc welding generator with all field windings in place

The time during which the arc remains short-circuited is quite short, being of the order of from 0.01 to 0.02 sec. Average time intervals between drops are approximately from four to five times the length of time on short circuit. The resistance of the metallic arc, therefore, varies rapidly between zero and a value which will make the potential drop across the arc at normal welding current equal to the normal arc voltage.

Variations in arc resistance resulting from metal transfer across the arc are much wider and much more rapid than those caused by the arc's inherent negative resistance characteristic. Because of the predominating character of these resistance fluctuations, the circuit to which an arc welding generator is delivering energy consists, from the standpoint of generating equipment, of a resistance which is periodically being short-circuited at a rate of from ten to twenty times per second.

## TREND IN DESIGN

Importance of minimizing the momentary current fluctuations, or transients as they frequently are called, is discerned clearly in the most recent modifications in the design of arc welding generating equipments. Publications which have appeared lately on the subject indicate that considerable effort has been directed toward that end. For example, in some makes of apparatus the well known reactor which has been used extensively to smooth out the current fluctuations has been modified to utilize impulses from it to speed up the flux changes in the generator field. One such modifica-

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Based upon "Recent Developments in Design of Arc Welding Generators" (No. 32-43) presented at the A.I.E.E. winter convention, New York, Jan. 25-29, 1932.

tion known as the "flexactor" has been described by Blankenbuehler (A.I.E.E. TRANS., V. 50, June 1931, p. 656-61) and another, the "transformer reactor," by Bergman (A.I.E.E. TRANS., V. 50, June 1931, p. 678-80). Apparently these modifications of the reactor have resulted in marked improvement in operation.

The desirability of eliminating the external stabilizer is recognized quite generally; however, to accomplish this requires that some means for stabilizing the arc be provided within the generator itself. On the basis of these and other known facts, then, it probably will be conceded that an ideal welding generator is one in which:

1. The external reactor has been eliminated, provided this has been accomplished without introducing undue complications.
2. Current impulses in the main circuit are reflected into the generator field to quicken magnetic flux changes and thereby make the machine more responsive to changes in the external resistance.
3. The exciter has been eliminated without resorting to a two-pole armature and four-pole field structure.
4. All regulating rheostats and switches have been eliminated without limiting the range or adjustment of welding currents.
5. Desirable arc characteristics are obtained over the whole range.

A generator which in the author's opinion fulfils these requirements now will be described briefly.

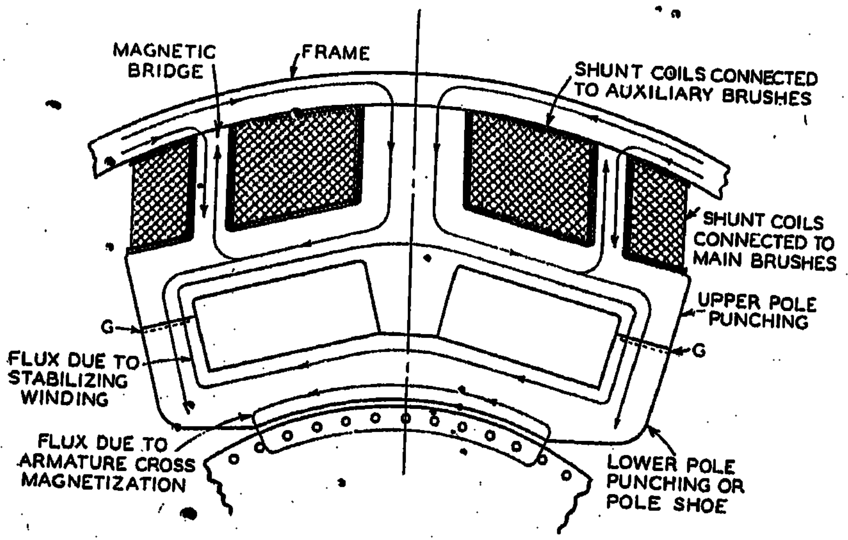

MAGNETIC BRIDGE
FRAME
SHUNT COILS CONNECTED TO AUXILIARY BRUSHES
SHUNT COILS CONNECTED TO MAIN BRUSHES
UPPER POLE PUNCHING
G
G
FLUX DUE TO STABILIZING WINDING
FLUX DUE TO ARMATURE CROSS MAGNETIZATION
LOWER POLE PUNCHING OR POLE SHOE

Fig. 2. Cross-section of generator main pole with the two shunt windings in place

Attainment of the first two objects enumerated has been made possible by a novel design of the commutating winding, shunt windings, and main poles; and by adding a special winding consisting of one turn short-circuited upon itself. The armature is similar to a standard d-c. armature, except that it is wound with a relatively large number of turns and has a correspondingly large number of commutator bars. In arc welding generators this is desirable for several reasons as will be shown in the following discussion.

With a large number of turns on the armature, it is recognized generally that a comparatively great change in the terminal voltage requires only a small change in the field flux; this makes the machine responsive to external resistance variations. With a high number of commutator bars, the volts per bar is low, which becomes a marked advantage in connection with the scheme of excitation to be described later.

In Fig. 1 is shown the field ring of the generator with all poles and field windings in place. It may be noticed that instead of being wound in the usual way on the commutating poles, the commutating coils have been extended to, and completely imbedded within, the main pole flanges. The commutating winding thus extended and surrounded by laminations functions as both a stabilizing and a commutating winding. The desired stabilizing effect thus is obtained without adding any windings to those ordinarily employed in commutating pole machines.

Method of assembling the pole flanges around the stabilizing winding can be observed readily from Fig. 1, assisted perhaps by reference to Fig. 2. As may be noticed, the pole is made up of two parts, the upper part being bolted to the generator frame. The stabilizing coil, which has been wound and formed to the proper curvature on a press, then is laid into slots in the upper part of the poles. Finally, the pole shoe is put in place and bolted to the upper part. This part of the pole serves as a common magnetic path for the stabilizing flux and the flux due to armature cross-magnetization.

From Fig. 2 can be noted also that the generator has two shunt coils separated by a magnetic bridge. The function of this arrangement and of the short-circuited winding is described in the discussion of an equivalent diagram of the electric and magnetic circuits. It may be pointed out here, however, that the axial length of the back of the pole—that is, the part bolted to the frame—is considerably shorter than the axial length of that part of the pole constituting the magnetic circuit of the stabilizing winding.

## EXCITATION AND CURRENT CONTROL

The well known reentrant volt-ampere curve of the shunt generator is not at all suitable for arc welding, since it is essential that the permanent short-circuit current be equal to or greater than the welding current.

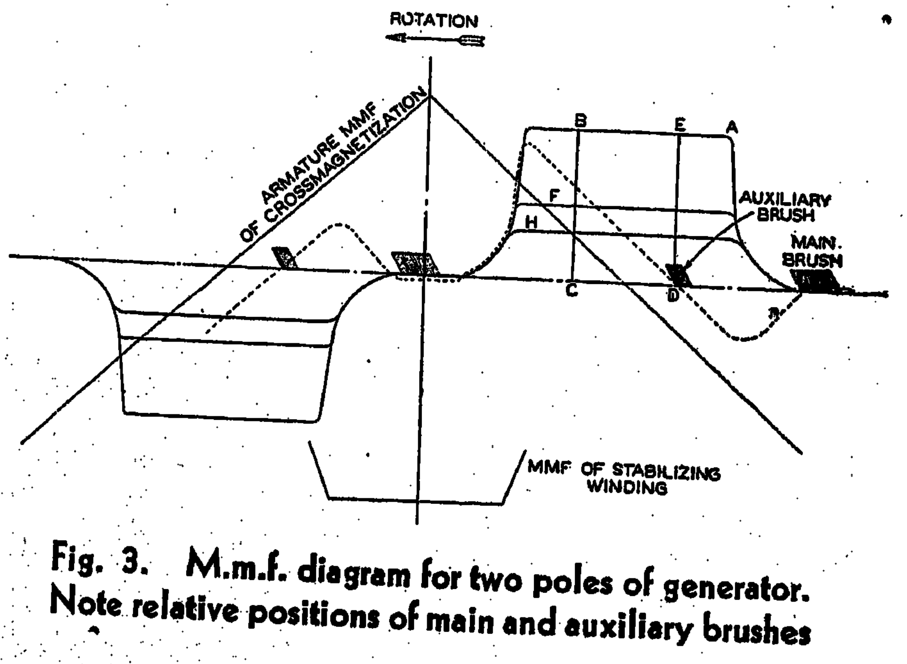

ROTATION
ARMATURE MMF OF CROSSMAGNETIZATION
B
E
A
F
H
AUXILIARY BRUSH
MAIN BRUSH
C
D
MMF OF STABILIZING WINDING

Fig. 3. M.m.f. diagram for two poles of generator. Note relative positions of main and auxiliary brushes

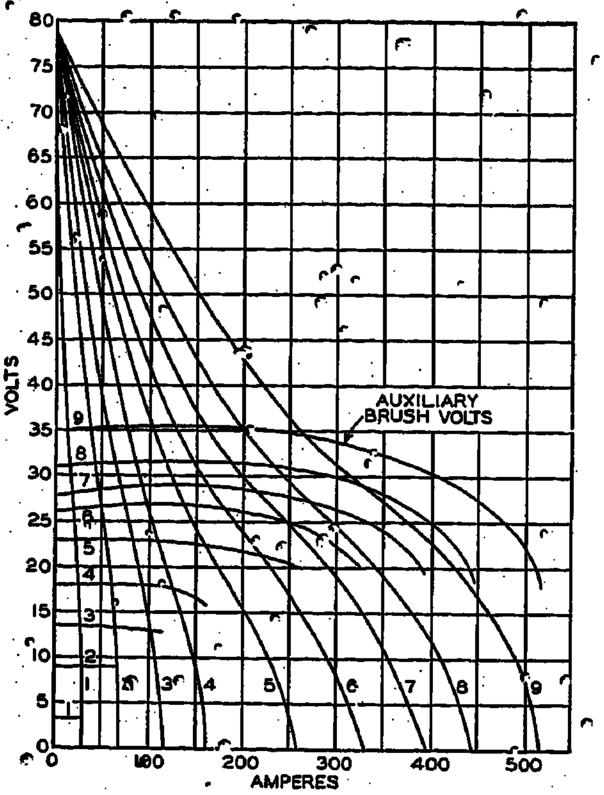


**Fig. 4. Volt-ampere characteristics and auxiliary brush voltage for different brush positions**

Main and auxiliary brushes are shifted together without altering their relative positions

For that reason some source of excitation must be available even on short circuit when the voltage across the main brushes is zero. Reference to Fig. 3 will show how this is accomplished.

In addition to the main brushes, the machine is equipped with two sets of auxiliary brushes spaced from 50 to 60 elec. deg. ahead of the main brushes. These excitation brushes have an unusually high contact resistance and can handle without commutation difficulties a much higher voltage per bar than ever is reached in these generators (which, as already pointed out, is unusually low). Line *A* represents the no-load field form, part of the negative portion of which is taken in by the auxiliary brushes. The voltage across the auxiliary brushes on open circuit therefore is proportional to the rectangle *BCDE*. The question that arises now is, "what will be the situation under some load conditions, for example, on short circuit?" First assume that magnetic saturation is negligible on short circuit so that fluxes are proportional to m.m.f's. Voltage in the shunt coil excited from the main brushes falls to zero on short circuit and the m.m.f. of this field is reduced to line *F*. In addition, a direct demagnetizing force from the armature reduces the m.m.f. on the field still further to line *H*. The remaining m.m.f's. are those due to the armature cross-magnetization and the stabilizing winding.

Distribution of flux in the air gap under the main poles is not affected directly by the m.m.f. of the stabilizing winding, but is affected indirectly by this m.m.f. when the pole shoe becomes saturated. Neglecting that for the moment, the flux distribution is the resultant of the net m.m.f. of the field and the m.m.f. of armature cross-magnetization. This is shown in Fig. 3 as a dotted line; the area included between this line and the base line, and lying above the base line, represents positive flux; similarly, the area below the base line represents negative flux. Thus upon short circuit, considerable positive flux still exists between the auxiliary brushes, whereas the net positive flux between the main brushes has been reduced greatly.

When the main and auxiliary brushes are shifted forward simultaneously, two phenomena become pronounced: The armature demagnetization is increased, and the voltage on the auxiliary brushes is decreased, both of which tend to reduce the current. Thus a wide variation in current can be obtained with a relatively small shift of the brushes. Actually the brushes are shifted by means of a micrometer screw arrangement, making possible minute gradations of welding current.

A set of volt-ampere curves of a 300-ampere welder is shown in Fig. 4. For the larger current values the voltage on the auxiliary brushes remains practically constant up to about normal current for that setting, and then drops off somewhat at short circuit. However, even at short circuit the auxiliary brush voltage is high enough to maintain a sufficiently large value of short-circuit current. For lower current values, the auxiliary brush voltage tends to remain substantially constant even at short circuit.

When the pole shoe, which as mentioned previously, carries the flux of both the stabilizing winding and the armature cross-magnetization, becomes saturated, the air-gap distribution and consequently the compounding of the auxiliary brushes are affected thereby. Saturation of the pole shoe can be modified, however, by introducing air gaps in the path of the stabilizing flux, as for example at points *G* in Fig. 2.

## MOMENTARY CURRENT FLUCTUATION AND ARC RECOVERY

To assist in forming a mental picture of the interactions between the various circuits during transient

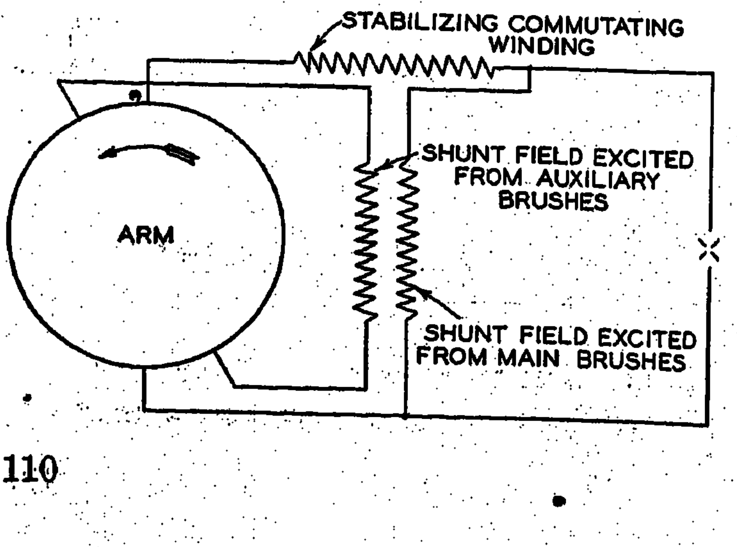
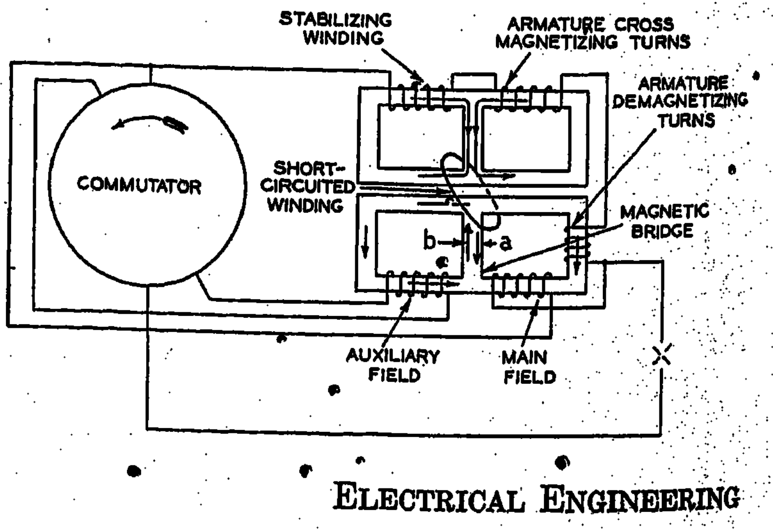

STABILIZING COMMUTATING WINDING
SHUNT FIELD EXCITED FROM AUXILIARY BRUSHES
ARM
SHUNT FIELD EXCITED FROM MAIN BRUSHES

**Fig. 5. Actual wiring diagram of welding generator without short-circuited turn (left)**

**Fig. 6. "Equivalent" diagram of generator and welding circuit (right)**



conditions, an *equivalent* circuit diagram of the generator is shown in Fig. 6. It should be understood that this is not an actual diagram of the circuit (compare with Fig. 5) the separation of the armature cross-magnetizing and demagnetizing turns, for example, being for convenience only.

The stabilizing winding and armature cross-magnetizing turns are shown opposing each other with a common magnetic circuit, the pole shoe, between them. The armature demagnetizing turns are shown opposed to the two shunt fields and it should be observed that the flux within these turns is responsible for the voltage at the main brushes. The magnetic circuit, encircled by the auxiliary field winding, is the main pole body, and the magnetic bridge is interposed between the auxiliary field and main field windings. In the absence of saturation no mutual induction exists between the stabilizing and the two shunt windings, so they have been shown as having separate magnetic circuits.

The two shunt coils are excited in the same direction; however, unless the main pole body is saturated, but little flux passes through the magnetic bridge on open circuit and this in the direction indicated by arrow *a*. On short circuit the m.m.f of the main field winding disappears and an opposing m.m.f. of armature demagnetization appears. Now a large amount of flux passes across the bridge, but in the direction of arrow *b*; that is, instead of reducing the flux in the main pole body (which flux interlinks with the auxiliary field winding) almost all of it is diverted through the bridge. The result is that the energy stored in the auxiliary field changes but very little as the terminal voltage varies. Advantages of eliminating the necessity for changing the energy stored in this field when the external resistance varies, are obvious.

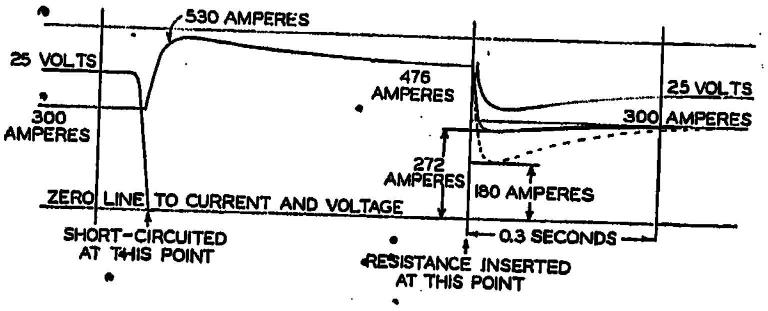


**Fig. 7. Replotted oscillogram of test made according to U.S. Navy specifications on 300-ampere welding generator**

Dotted line represents current drop and recovery time permitted by Navy specifications

To make still faster the response of the machine to variations in the external resistance, the short-circuited winding is made to form a link between the stabilizing and the field windings. When the current in the stabilizing winding increases rapidly, a current will flow in the short-circuited winding which assists in reducing the field flux. When the current in the stabilizing winding is decreasing rapidly, the transient current in the short-circuited winding assists in building up the main flux. With this method of utilizing impulses from the arc circuit to speed up flux changes in the field, no high potentials are generated in any circuit at any time to subject the insulation to undue strain.

### Some Tests on the New Machine

The A.I.E.E. test of a welding generator for momentary current fluctuation and arc recovery is as follows: Adjust generator on resistance load to obtain normal current at 25 volts; short-circuit one-half the resistance and allow current to settle; then suddenly open the short circuit and reinsert the resistance in the circuit. The current momentarily drops below normal and the *time of recovery* is the time required for the current to return to within 5 per cent of its original value.

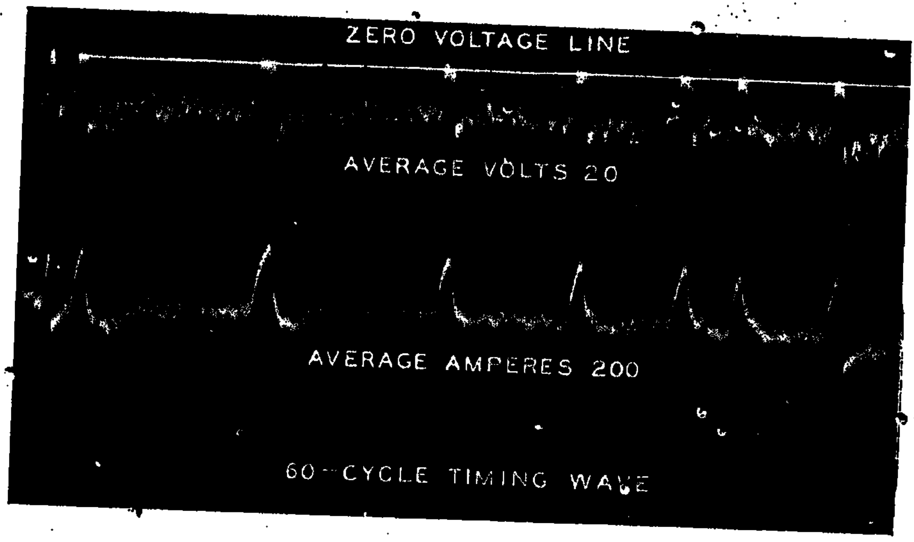


**Fig. 8. Oscillogram record made during an actual welding operation with the new generator**

This test is of little value because the resistance variation is not wide enough to cause any noticeable depression of current below normal upon reinserting the resistance circuit; that is, not if the machine is worthy of being termed an *arc welding generator*. United States Navy specifications, however, call for the same test for arc recovery with the exception that all of the resistance must be short-circuited and then reinserted. This test means something.

A replotted oscillograph record of a test made according to the latter specifications at normal load on a 300-ampere welder of the type just described is shown in Fig. 7. The dotted line indicates the drop in current and the time of recovery permitted by the Navy specifications. It may be noticed that whereas the Navy permits the current to drop to 180 amperes, for this machine it actually drops to only 272 amperes. In Fig. 8 is shown an oscillograph record made when welding with a bare, mild steel electrode, and with an average welding current of 200 amperes and an average of 20 volts across the arc.

# A Corona Tube Voltage Regulator

A corona tube may be used to regulate the output of a full-wave rectifier and therefore to control the excitation of a generator to give constant voltage. Performance curves for a five-kva generator whose voltage is controlled by such a regulator indicate advantages over other types.

By
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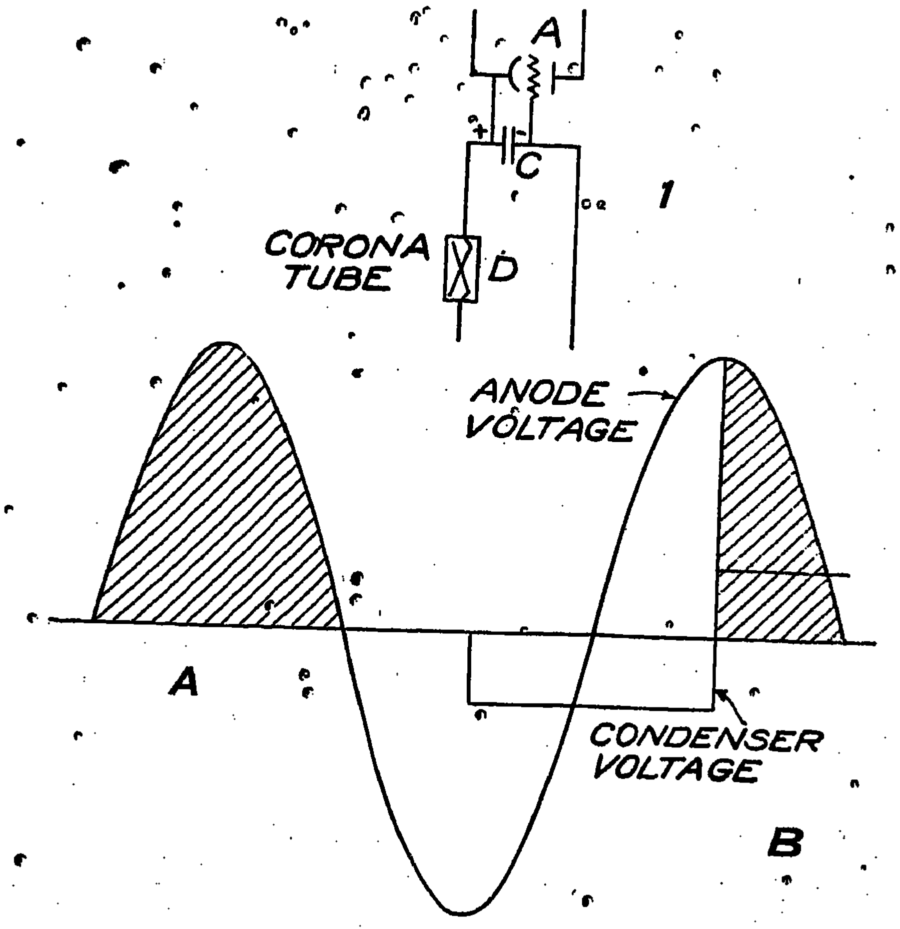

Fig. 1. Voltage wave and simplified circuit of corona tube and rectifying tube

A VOLTAGE REGULATOR consists essentially of a constant element; an element which varies with the voltage and which is balanced against the constant element; and an arrangement for using this balance to control the excitation of the machine whose voltage is to be regulated.

In the familiar vibrating contact regulator the modulus of elasticity of a spring is the constant element. Acting against the spring is the pull of a solenoid which is dependent upon the voltage. The forces due to the solenoid and the spring act on a plunger which operates a contact by which resistance is put into or taken out of the generator field circuit, thereby regulating the generator voltage.

The most serious disadvantages of the vibrating contact regulator are:

1. Wear and sticking of the contacts.
2. Periodic fluctuations of the voltage with opening and closing of the contacts.
3. Slow response to fluctuations of the voltage, due chiefly to the time lag of the field circuits of the exciter and the generator.

Recently a number of new types of regulators has been devised. Almost any phenomenon which varies with voltage may be made the basis of a voltage regulator, such as the saturation of an iron core reactor, the resistance of a conductor heated by the voltage, or the internal resistance of a thermionic tube whose filament is heated by the voltage. The regulator described below employs the critical voltage of a corona tube as the basic phenomenon.

The corona discharge tube employed consists of two symmetrical electrodes sealed into a glass tube containing an inert gas at a suitable pressure. Due to the fact that the tube contains a definite quantity of gas constrained to a fixed volume, the mean free path of an ion and therefore the corona voltage are practically independent of the temperature. Since ionization builds up very quickly at a voltage above the critical value, the breakdown voltage is also independent of the frequency, for frequencies within the commercial range. With the electrodes surrounded by an inert gas such as argon there is negligible disintegration of the electrodes during discharge; the breakdown voltage of the tube is constant and the life very long.

These characteristics of the corona discharge tube make its critical voltage suitable for the constant element in a regulator. The fact that it regulates to a constant peak voltage rather than a constant effective voltage is not a serious disadvantage, for the variation of wave form with load is not appreciable and there will therefore be a constant form factor.

In order to control the excitation of a generator we may use the charge passing through the corona tube above the corona voltage to bias the grid of a rectifying tube and thereby regulate the amount of rectified current which will be supplied to the generator field. Any type of rectifying tube may be used. However the high efficiency and large amplification factor of a gaseous tube, such as the thyratron, make this type of tube very desirable.

In order to explain the principle of operation, the simplified circuit shown in Fig. 1 will be considered first, and the voltage applied to the anode and cathode of the rectifying tube will be assumed to be in phase with the

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From "A Corona Tube Voltage Regulator" (No. 31-112) presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

voltage in the corona tube circuit. The thyratron tube *A* has a negative grid characteristic, and it therefore normally conducts current into the field of the generator during the half wave when the anode voltage is positive, as indicated by the shaded positive half cycle. During the half wave when the anode voltage is negative the condenser *C* will be charged as indicated by the polarity marks, provided the circuit is connected with the proper polarity and provided the voltage rises above the critical value for the corona tube. During the first part of the next positive half wave the thyratron cannot conduct current because the grid is negative. However the grid bias will be reversed by the corona tube at the peak of the voltage wave, and the thyratron will conduct current during the latter half of the positive voltage wave as shown by the cross-hatched area. In this way the average value of the rectified current will be reduced to one-half the full half wave or maximum value when the voltage is above the breakdown value for the corona tube.

If a voltage is impressed on the corona tube which lags in phase behind the rectifier voltage, the average current may be reduced to less than 50 per cent of its maximum value because the grid bias will then be reversed after the peak of the voltage wave. When the corona tube is supplied from a voltage 60 degrees behind the rectifier voltage as in a three-phase machine, the corona tube will reduce the average current to 7 per cent of the maximum value.

The circuit as described above will vary the excitation by definite steps and will give fluctuations in the excitation just as are produced by opening and closing the contacts of a vibrating regulator. However if a leak is placed across the grid biasing condenser of a value such that the time constant *CR* of this condenser and leak is about equal to the period of one-half wave, then the grid condenser voltage may be reduced by leakage to a value where the thyratron will start. The time it will take to reduce the grid voltage to the starting value will depend on the initial charge of the grid condenser, and this is determined by the excess of the voltage above the critical voltage of the corona tube. Therefore the time of starting for the thyratron rectifier in any half wave will be delayed by an amount which is determined by the excess of the voltage above the breakdown voltage of the corona tube. This is indicated in Fig. 2. A small rise in total voltage above the critical value will serve to reduce the rectified current to about 7 per cent of its maximum value. However this change is continuous.

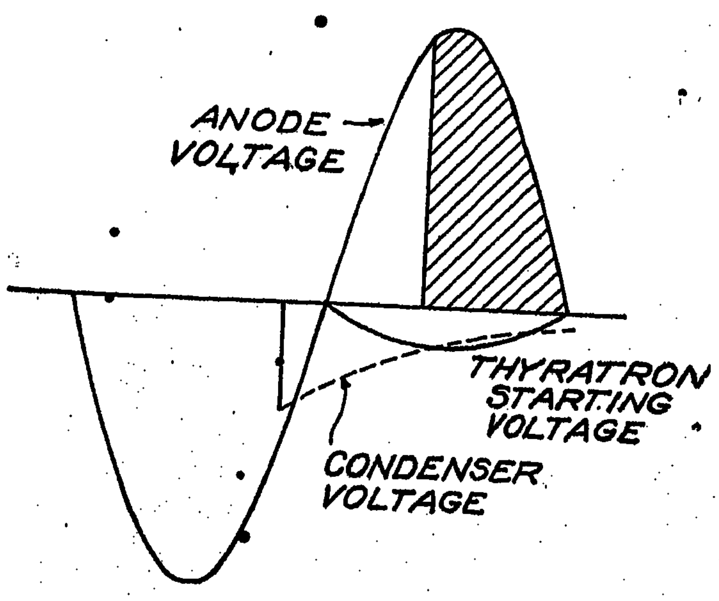

**Fig. 2. Voltage waves with leak across grid biasing condenser**

The circuit used for controlling a full-wave rectifier by means of a corona tube is shown in Fig. 3. It was found quite difficult to make corona tubes so symmetrical that they would break down at the same voltage on the positive and negative half waves. However by adding the condenser $C_4$ shown in Fig. 3 it is possible to eliminate any unidirectional components of current and cause the corona tube to have the same positive and negative critical values.

In the regulator used for the results given below, the thyratrons were too small to rectify the entire field current and their output was used for the field of an exciter.

In this case a further difficulty arose in the time

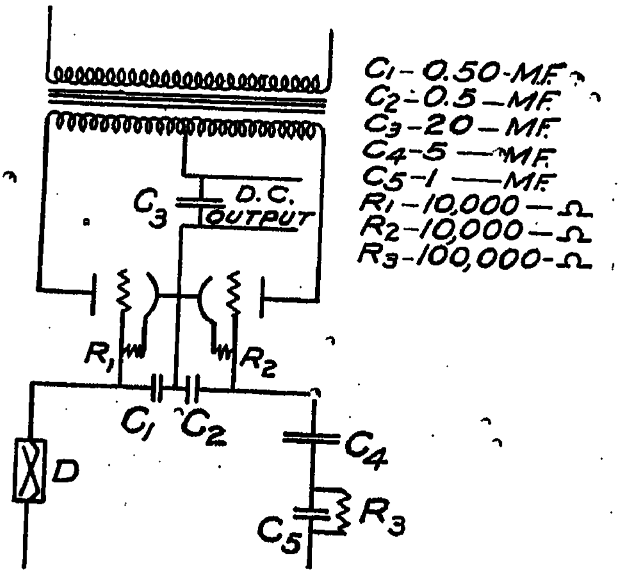

**Fig. 3. Corona tube voltage regulator circuit for full-wave rectification**

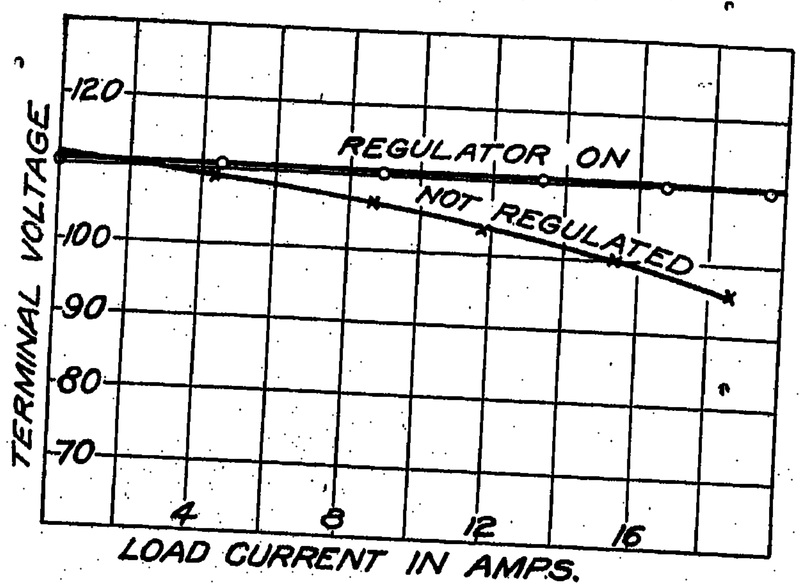

**Fig. 4. Voltage regulation with variation in generator load**

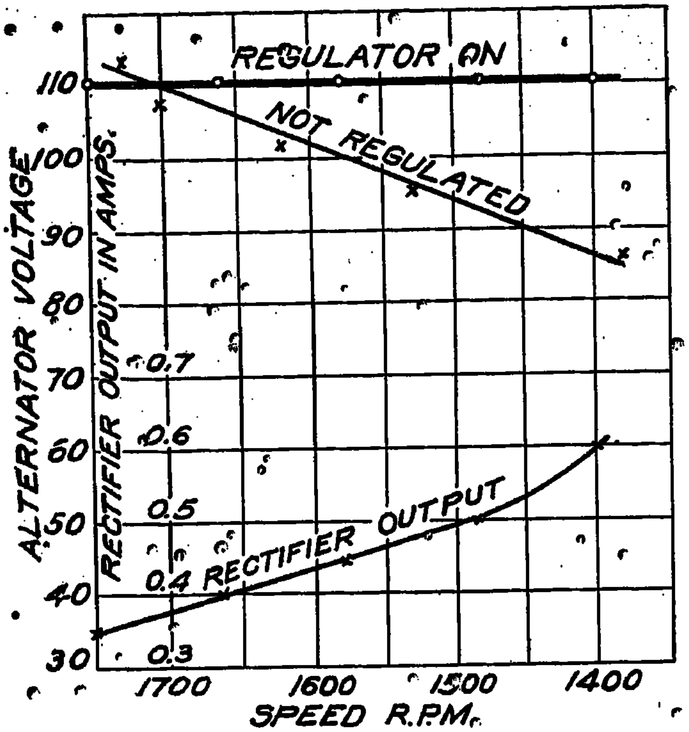

Fig. 5. Voltage regulation and rectifier output with variation in exciter speed

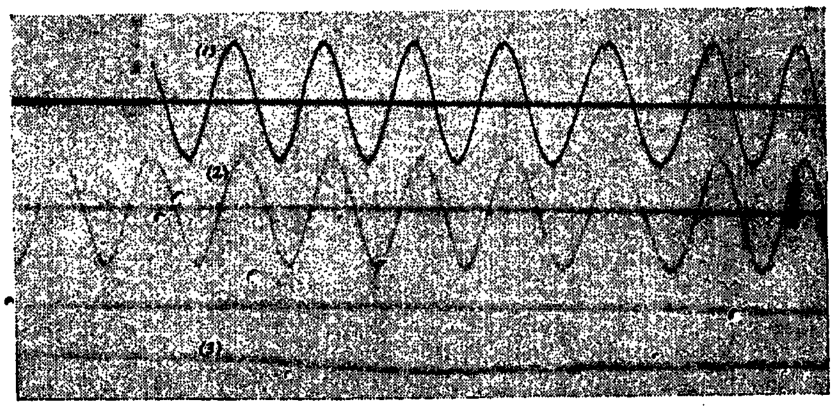

Fig. 6. Oscillograms of (1) load current, (2), alternator voltage, and (3) regulator output when suddenly applying full load to generator

lag of the exciter and alternator fields in responding to a change in the rectifier output. This caused oscillations of the generator voltage of about the period of the time constant of the field circuit. It was found possible, to suppress these oscillations by introducing into the corona tube circuit a transient of about the same period as the oscillations. This transient is introduced by a condenser with a leak as shown at $C_5$ and $R_3$ of Fig. 4, such that $C_5R_3$, the time constant, is about equal to $L/R$, the time constant of the slowest field circuit.

The constants of the regulator circuit as used are shown in Fig. 3. The critical voltage of a corona tube with given dimensions and gas pressure may be predicted from the data giving the corona voltage of the gas to be used. The tube as used contained argon at a pressure of two centimeters of mercury. The electrodes were parallel wires 0.25 mm. in diameter and separated 1 cm. The critical voltage of this tube was approximately 350 volts peak value.

The results shown in the curves of Figs. 4 and 5 were taken on a five-kva. three-phase motor-driven alternator excited from a 110-volt motor-driven exciter. In the curves of Fig. 4 the effects of load variation are shown while Fig. 5 shows the regulation when the speed of the driving motor is varied. The oscillograms in Fig. 6 shows the transient conditions when full load was suddenly thrown on the generator.

This type of regulator would employ the same methods of compounding and line drop compensation now in use. It is believed that the simplicity, compactness, high sensitivity, and quick response of this corona tube regulator offer advantages over the other types.

# Photoelectric Recorder Has High Sensitivity

**A new recorder has been developed which employs for the measuring and recording operations separate elements coupled together by a combined optical and photoelectric system. Tests show that the new instrument is as accurate, sensitive, and responsive as a good indicating instrument.**

By
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AS SOON AS an instrument is developed which is capable of *indicating* the value of any quantity, attempts usually follow to make its function partly automatic by having it *record* its readings. Ordinary direct-acting recorders are the heavier and higher-torque counterparts of corresponding indicating instruments; although such recorders have some highly desirable characteristics, such as rapid response and the furnishing of a continuous record, their sensitivity cannot be made to approach that of indicating instruments. In other cases it is desirable to utilize the instrument for controlling the indicated quantity. These additional requirements involve the performance of mechanical work but in many cases the necessary additional energy is not available from either the instrument or the mea-

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Based upon "The Photoelectric Recorder" (No. 32-15) presented at the A.I.E.E. winter convention, New York, Jan. 25-29, 1932.

sured circuit. Thus in the past the application of indicating instruments to recording and control operations has not been possible beyond certain limits.

The photoelectric recorder described in this article combines all of the advantages of direct-acting recorders with those of the most sensitive indicating instruments. This is accomplished by providing a separately excited recording element to do the actual work of making the record. A sensitive indicating instrument controls the position of the recording element so that the record obtained represents the readings of this basic instrument. The loss in the sensitive basic instrument is the only power required from the measured circuit.

A combined optical and photoelectric system is utilized to link together the basic and recording elements of this new instrument. The basic element itself rotates a galvanometer mirror through an angle corresponding to its reading, and can be made even more sensitive than the usual indicating instruments of the pointer type. Furthermore, the recording element may possess as much torque as required and be made as heavy and sturdy as desired without affecting the basic element or measured circuit in any way. As a result, the photoelectric recorder possesses all of the desirable characteristics of direct-acting recorders, and at the same time is capable of a sensitivity and a rapidity of response equal to that of the highest sensitivity indicating instruments.

An interior view of this new recorder is shown in Fig. 1. The instrument is completely self-contained and requires only an auxiliary power source of 115 volts, 60 cycles; it is available for either portable or switchboard use. Internal parts of the recorder may be grouped into five units: (1) the basic indicating instrument or galvanometer; (2) the optical system; (3) the recording element; (4) the chart carriage; and (5) the power unit.

The basic instrument is the only *measuring* device within the recorder. It may be similar to almost any ordinary indicating instrument or galvanometer element, but the particular basic instrument used determines the sensitivity and rapidity of response of the resulting recorder.

A schematic diagram of the optical system may be seen in Fig. 2. In general this arrangement comprises a group of reflectors so arranged that an angular displacement between the recording and basic elements will cause a shift in light distribution between the photoelectric tubes, which in turn reacts on the recording element to reduce the displacement to zero. Thus the optical system acts to maintain the recording and basic elements in the same angular position at all times. How this is accomplished may be determined by inspection of Fig. 2. The important reflectors are: the basic element mirror *A*, the curved reflector *B*, recording element mirror *C*, and finally, the dividing reflector *D*.

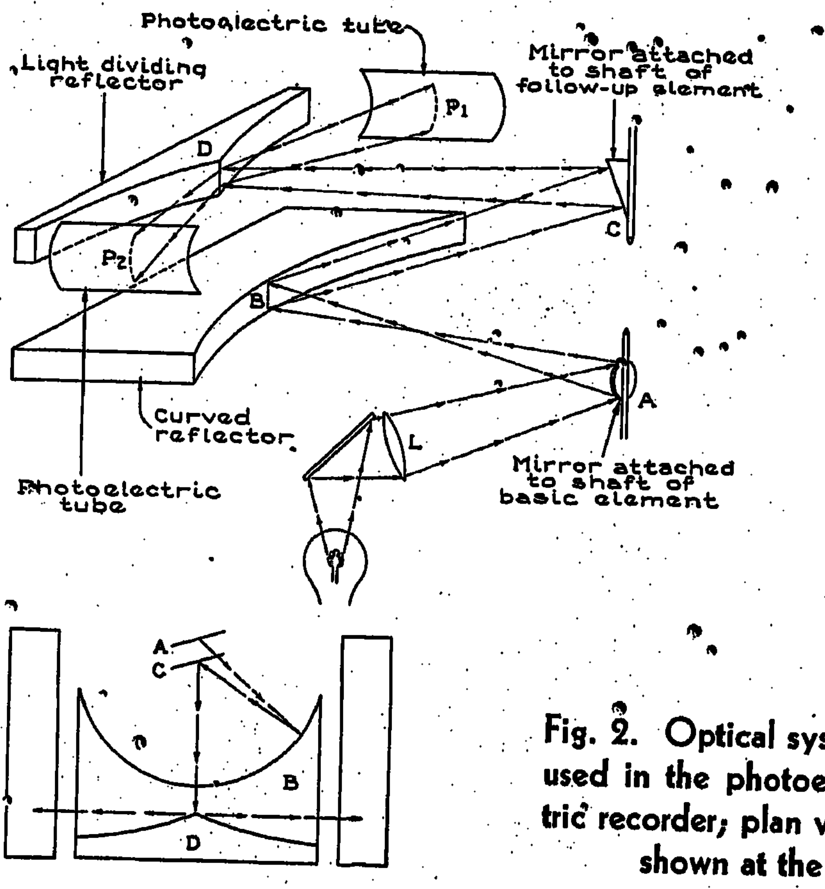

**Fig. 2. Optical system used in the photoelectric recorder; plan view shown at the left**

The recording and basic elements usually are mounted on the same axis, or very nearly so, although this is not necessary for successful operation of the instrument. The lamp and condensing lens converge a beam of light upon the basic element mirror *A* from which it is reflected to the curved mirror *B*. The point where the light strikes mirror *B* will depend upon the angular position or "reading" of the basic element, but regardless of where it strikes *B* it is reflected to mirror *C* attached to the shaft of the recording element. From *C* the beam is reflected to *D* at an angle depending upon the angle of reflection from *B* and also upon the position of the recording element. When *C* and *A* are parallel, however, the light will split evenly upon the dividing edge *D*; this

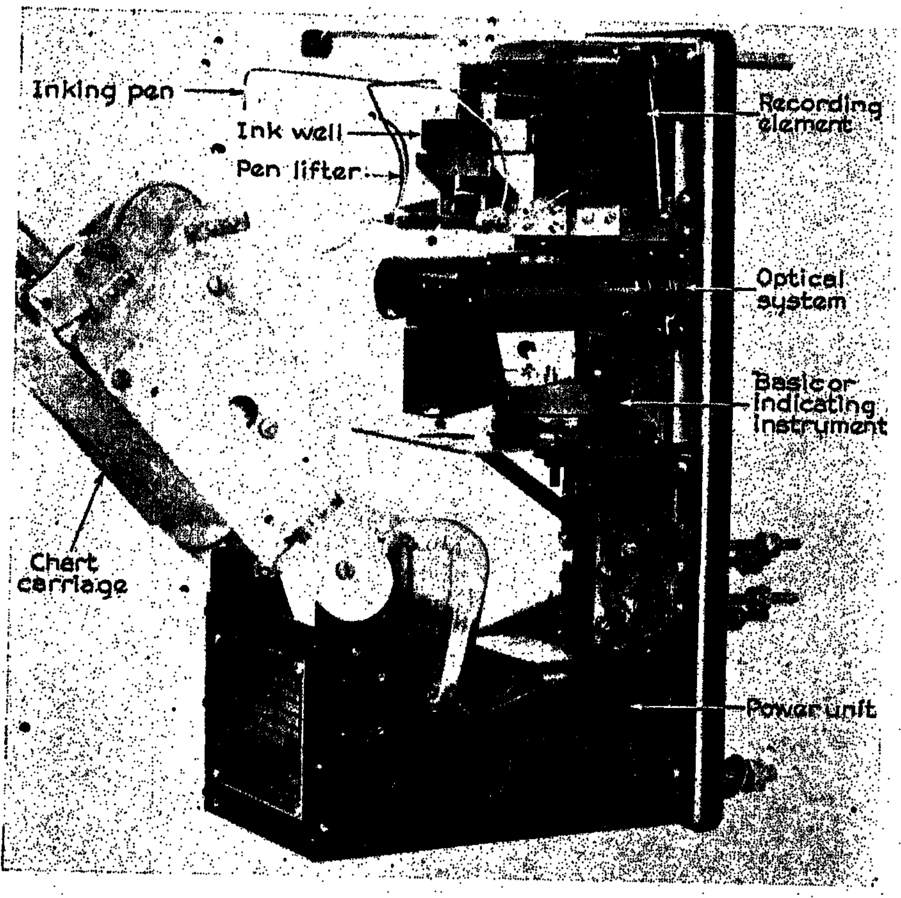

**Fig. 1. Interior view of one type of photoelectric recorder with chart carriage tilted out**

holds regardless of the actual positions of *A* and *C* so long as they are parallel to each other. If they are not in this parallel position, the light will strike to one side of the edge of *D*; more of it thus will pass into one photoelectric tube than into the other and cause the recording element to turn until *A* and *C* are parallel. Relations between the various angles of incidence and reflection are shown in the plan view shown in the lower right hand corner of Fig. 2; by slightly displacing the mirrors from their true positions, the different paths of light can be traced readily.

Power to operate the recording element is controlled by the photoelectric circuit (See Fig. 3). Of greatest importance is that part of the circuit beyond the field coils of the recording element. A portion of the d-c. voltage across the field coils is applied to the three-element pliotron tube; the plate current of this tube passes through the recording element armature connected in the filament side of the circuit to permit grounding one armature lead. Another portion of the voltage across the field coils is applied to the two vacuum type photoelectric tubes which are connected in series with their common junction connected to the grid of the pliotron.

This circuit possesses very high sensitivity to changes in the distribution of illumination between the two tubes so that the slightest unbalance of light in either direction between the tubes will throw the grid voltage to one extreme; a slight unbalance in the opposite direction will throw the grid voltage to the opposite extreme. These extreme grid voltage swings occur far too fast under normal conditions to make the circuit useful for purposes of recording. However, the response of the circuit may be made as slow as desired without sacrificing the high sensitivity and its obvious advantages. This is accomplished by inserting a capacitor and resistor in series between the grid and filament of the pliotron tube. With these added to the circuit it is necessary to alter the charge upon the capacitor before the grid voltage can change, and the time lag of this procedure may be adjusted to any degree by changing the value of the capacitance. Without the damping capacitor and resistor violent hunting would take place between the recording element and the photoelectric circuit, whereas with the damping circuit in use, all tendency to hunt or overshoot can be eliminated completely.

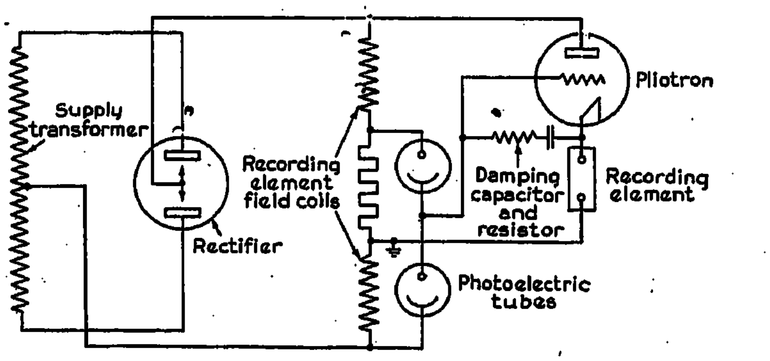

Fig. 3. Photoelectric circuit for controlling the recording element

The recording element may be any ordinary sturdy unit which will produce sufficient torque from the output of the pliotron tubes. Likewise the inking system and chart carriage may be of conventional design.

### ACCURACY

In any new instrument all possible sources of error should be investigated carefully. The mere mentioning of a possible source of error, however, should not be interpreted in any way to mean that that particular source is an important one; in fact all known factors which might affect the accuracy of the instrument are mentioned mainly for the purpose of showing how extremely small are their possible effect.

Variation in the supply voltage does not affect the accuracy of the photoelectric recorder within rather wide limits. Voltage changes are automatically compensated for by corresponding changes in the recording element current and thus produce no discernible effect upon the record. Changes in vacuum tube characteristics also are automatically compensated by the circuit in the same manner as are voltage fluctuations. Changes in lamp illumination caused by variations in the supply voltage, deterioration of the filament or blackening of the bulb, ordinarily do not produce any effect upon the recorder during the life of the lamp. Changes in illumination also may result from the reflectors becoming dusty or fogged. These variations in illumination may cause a noticeable slowing down of the operation of the instrument but do not affect its accuracy in any way.

Variations in photoelectric tube sensitivity may be cited as another possible source of error. Proper design of the optical system however has reduced the effect of such changes to a secondary and negligible order of magnitude. It has been found that errors due to this cause are limited at most to a few tenths of one per cent, and this only after a considerable period of time. Resetting the instrument on zero at occasional intervals would eliminate the possibility of even this small error. Other possible minor sources of error include vacuum tube grid currents, photo tube dark currents, and leakage currents in the grid circuit. All of these tend to react in the same manner as changes in the photoelectric tube sensitivity. The magnitude of all stray currents, however, may be reduced without difficulty to from one-tenth to one-twentieth of the actual control current, so that the effect is entirely negligible.

Upon the basis of the foregoing it may be said that a photoelectric recorder is practically self-compensating for all normal changes in supply voltage, lamp illumination, and vacuum tube and photoelectric tube characteristics. Tests made so far indicate that this recorder has a sustained accuracy over long periods in the same order of magnitude as would be expected from a high grade indicating instrument.

# The Kindling of Electric Sparkover

**Experimental evidence is presented which tends to prove that electrons and not protons or positive ions are the active carriers in the spark kindling mechanism and that Lichtenberg figures form the initial step in the process.**

By
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ELECTRIC SPARKOVER and the kindling mechanism by which it takes place recently has become the subject of much discussion. Results of investigations already made furnish ample evidence that the process is extremely complex and that the speed of formation is in the order of $10^8$ cm. per sec. instead of $10^4$ or $10^5$ as previously thought. Many factors such as polarity, shape of electrodes, ionization, space charges, voltage gradients, air pressure, and temperature, also are known to affect the process. Although previous investigators have been able to throw some light upon certain phases of the initial or kindling stage a comprehensive explanation of the complete process still is lacking.

The investigation described in this article presents a new method of approach to the problem and the results furnish additional information concerning the kindling period, that is, the first few microseconds of the sparkover process. Apparatus used in the tests has been described previously (A.I.E.E. TRANS., Vol. 49, 1930, p. 1384). It consists essentially of a specially designed air-tight photographic plateholder (see Fig. 1) which is placed in the field of a powerful electromagnet. Voltage impulses forming the Lichtenberg figures are impressed upon two electrodes the ends of which are held in contact with the sensitized surface of the photographic plate. The apparatus is arranged so that the field of the electromagnet is at right angles to the plate the desired pressure inside being maintained by means of a vacuum pump connected as shown. To simplify the discussion and particularly any references to illustrations, the direction of the magnetic field will be designated by the letters *S* and *N*, *S* indicating that the plate-holder was placed in the field so that the south pole is in front of the printed page, and *N* indicating the reverse.

A graphical representation of the path which an electron would follow on the emulsion surface of the plate in passing from the negative to positive electrodes under combined stress of dielectric and magnetic fields is given in Fig. 2, direction of the magnetic field being assumed as *S*.

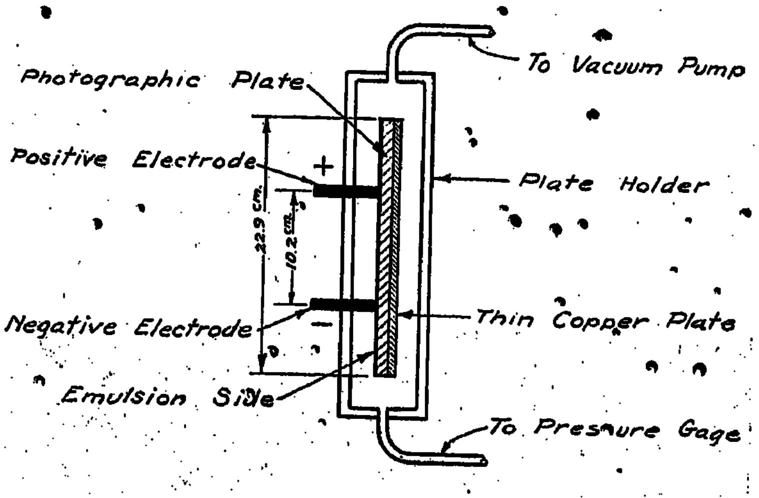

Fig. 1. Cross-section of air-tight plate-holder

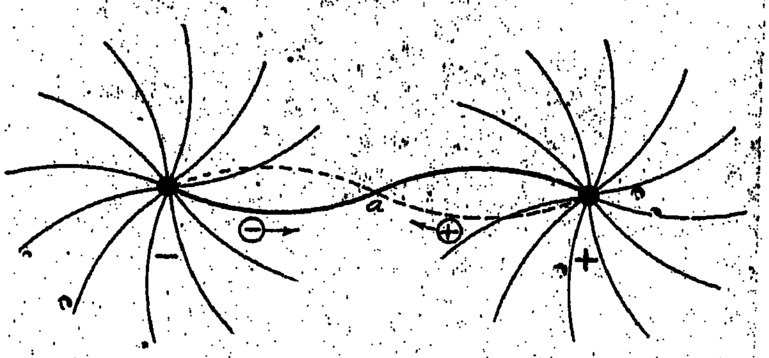

Fig. 2. Graphical representation of electron and proton paths between two electrodes under the combined stress of dielectric and magnetic fields

Consider an electron projected from the negative electrode under the given conditions and passing through the point *a* midway between the two electrodes. The electrostatic force of repulsion from the negative electrode and attraction to the positive electrode combined with the reaction from the magnetic field at right angles to the direction of motion, will cause the electron to move along a path similar to that indicated by the solid line. It is evident that under the combined action of the dielectric and magnetic fields the paths of *all electrons falling into the positive electrode* will move in paths bending in the counterclockwise direction, with reference to the positive electrode. Hence, if *electrons* be the active elements in the sparkover process the path followed by the spark should have a double inflection as illustrated by the full line in Fig. 2. On the other hand, if positive ions or *protons* be the active elements in the sparkover mechanism the path followed by the spark likewise should have a double inflection, but must be curved in the reverse direction, as indicated by the broken line in Fig. 2.

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From "The Kindling of Electric Sparkover Based on Lichtenberg Figures," (No. 31-123) presented at the A.I.E.E. Pacific Coast convention, Lake Tahoe, Calif., Aug. 25-8, 1931.

Deflections of the sparkover path therefore can be used as a criteria in determining whether electrons or protons are the active elements in the sparkover process.

On the basis of the foregoing discussion consider the three sparkovers recorded in Fig. 3. In *b* the field direction was *S*, the same as used for the diagram in Fig. 3. The sparkover path has a double deflection exactly like that of the solid line curve in Fig. 2. In *a* and *c* the direction of the field was *N*, that is, reversed as compared to the direction in *b*; deflection of the sparkover paths in *a* and *c* also are reversed as compared to *b*. It is evident therefore that according to the argument advanced in the preceding paragraph, electrons were in each case the active elements in the kindling stage.

By reducing the air pressure within the plate-holder the bending effect of the magnetic field is increased, and deviation of the sparkover path from a straight line increases proportionately. A series of sparkover photographs accordingly were taken at air pressures ranging from atmospheric to 0.02 mm. Hg. The double inflection of the curve, in each case, followed the path that would be taken by negative charges, that is, electrons, as illustrated in Fig. 2 by the solid line.

The sweep of the nebulous positive figure, when formed at low air pressure and under the stress of the magnetic field, is revealed in Fig. 4. The double inflection of the sparkover path, arrested before complete sparkover occurred, is very marked, and is in complete accord with the analysis of the electron path (solid line) indicated in Fig. 2. There is no evidence of a counter flow of positive ions or protons in either this or any of the other photographic records.

## CONCLUSIONS

Although the number and range of experiments made on Lichtenberg figures on sparkovers formed under stress of magnetic fields are limited, the results obtained together with the many important relations previously determined seem to warrant the following observations:

1. Lichtenberg figures represent, or are formed by, elementary electric sparks. On this basis the process of formation of these figures would represent also the kindling mechanism of the simplest form of sparks.
2. Lichtenberg figures or the electric sparks producing them form the initial step in the sparkover process.
3. Sparkover develops from the tips of the positive Lichtenberg figures and tends to follow the positive and negative streamers.

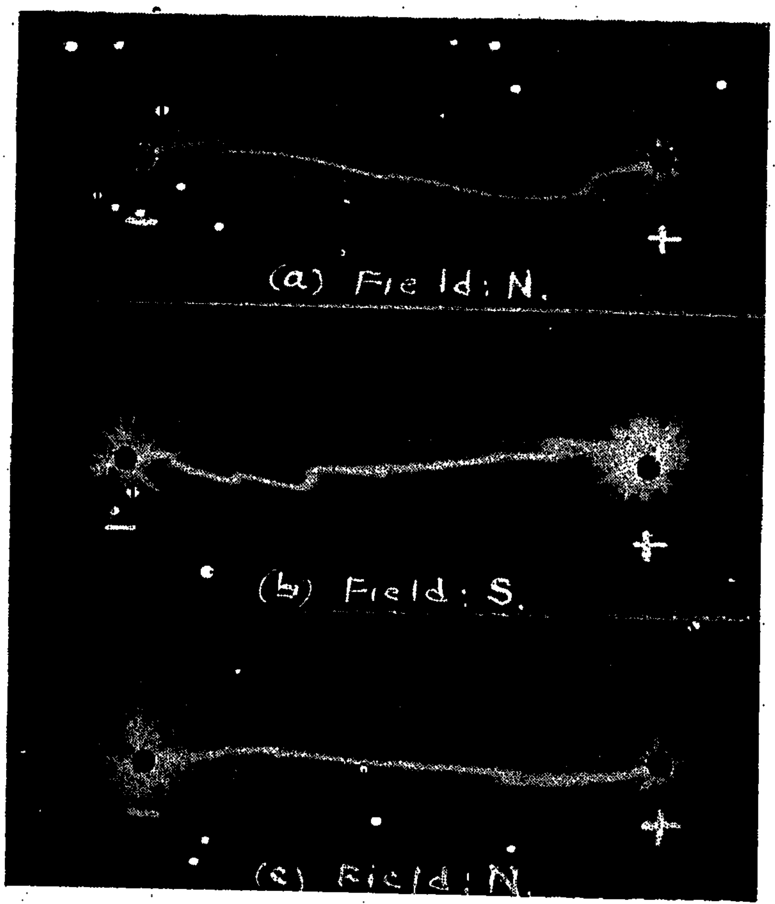

**Fig. 3. (Above) Lichtenberg figures and sparkover-paths for three cases**

Air pressure,—15 cm. Hg.
Field,—12,500 lines per sq. cm.
Electrode spacing,—5 cm.

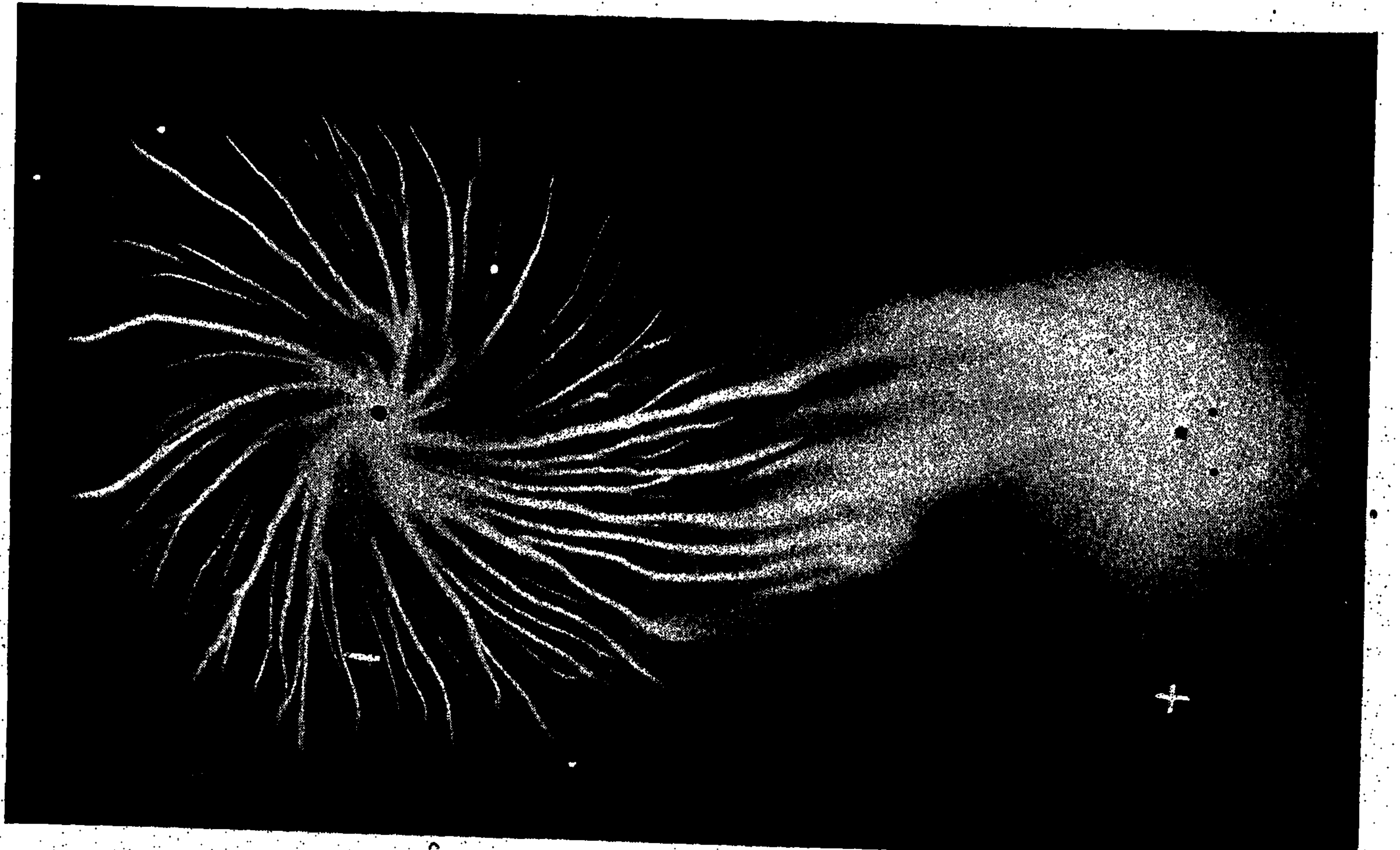

**Fig. 4. (Right) Typical Lichtenberg figures of arrested sparkover at low pressure**

Air pressure,—1.3 cm. Hg.
Field,—S, 5,160 lines per sq. cm.
Electrode spacing,—10.2 cm.
1 megohm resistance in series with gap

# Reestablishing Excitation of a Loaded Alternator

**Operating tests on large turbine-generators indicate that following the accidental opening of the field switch of a loaded machine, service should be restored by closing this switch as soon as possible, without removing the generator from the bus.**

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Both of
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SWITCHBOARD operators in generating stations are at times suddenly confronted with troubles which call for immediate action. Such a situation results with the unexpected opening of the field switch of a loaded generator, and the operating rules of different power companies are by no means in agreement as to the proper procedure in this emergency.

In an attempt to determine exactly what happens when the field switch of a large alternator is opened and a short time later reclosed, a group of tests was conducted. The most interesting of these tests is illustrated by Fig. 2 which is a faithful reproduction of oscillograph records. These were taken on the cross-compound 60,000-kw. 60-cycle 12,000-volt unit illustrated in Fig. 1. The high pressure generator is rated at 1,800 r.p.m. and has 5.8 ohms synchronous impedance, while the low pressure generator is rated at 1,200 r.p.m. and has 1.92 ohms synchronous impedance. The external reactors between the unit and the bus are 827-kva., 3,500-ampere, and have 3 per cent reactance at 12,000 volts.

As illustrated in Fig. 2, the machine was carrying 50,000 kw. at 80 per cent power factor lagging when the switch was opened. The total load lost following the opening of this switch was 40 per cent. Root-mean-square values of armature current and voltage are shown, the field current and turbine speed being instantaneous values.

The action of both units of the machine is evident from the oscillograms. Upon opening the field switch, the generator field was short-circuited by discharge resistors and the field currents of each unit almost immediately dropped to less than half value. Then for a period of four seconds the fields gradually became demagnetized, the station bus voltage dropped, and the armatures gradually drew heavy magnetizing currents from the system. Following this and until the field switch was reclosed, transient conditions existed with both machines running considerably above synchronous speed. The speed of the high pressure turbine was very erratic and violent governor action was observed. The low pressure turbine, not having a speed regulating governor, ran at a more uniform speed. A further reason for the steadiness in the speed of the low pressure turbine can probably be found in the fact that the reheat boiler served as a stabilizer for the rapidly pulsating steam that was passing through the high pressure turbine. Since the heat in the reheat boiler was constant it momentarily would give off more reheat to a smaller amount of steam at a lower pressure, and less reheat to a larger amount at higher pressure.

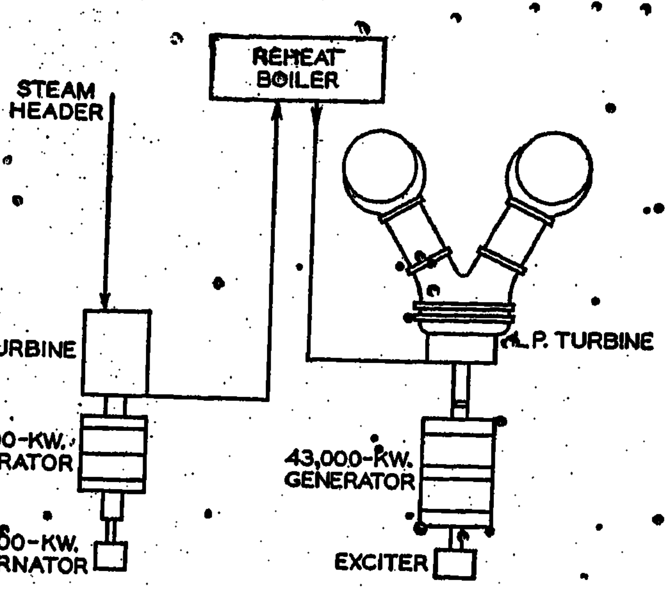

**Fig. 1. Plan of two-element 60,000-kw. turbine-generator unit No. 2 at Crawford Ave. station**

As the magnetic coupling between the field and the armature poles was removed on the opening of the field switch, the energy produced by the turbine accelerated the machine above synchronous speed. The field winding then cut lines of force and had induced in it a current which had a frequency proportional to the slip; that is, the difference between the armature speed and field speed. The general characteristics of the machine were those of an induction generator. The governor on each machine prevented it from reaching an excessive speed, and the necessary exciting current was drawn from the line.

As indicated by the oscillograms the field currents reversed each time a field pole passed over an armatures pole. The armature currents plotted as r.m.s. values are seen to have a maximum and a minimum value for each reversal of the field current. Ordinarily an induction generator would have constant armature current for a given speed. The peak values found on these tests may be explained by the fact that the field does not have a uniformly distributed winding such as would be found in the rotor of an induction machine.

Whether or not the shunt wound exciter would have

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Based upon "Reestablishing Excitation of a Loaded Alternator in Parallel with Others" (No. 31-101) presented at the A.I.E.E. summer convention, Asheville, N. C. June 22-26, 1931.

become demagnetized if the field switch had been closed when the induced field current was a maximum in the reverse direction was not definitely determined. However, in the worst case found in these tests the low pressure field was 550 amperes in the reverse direction and passing through a discharge resistance of 0.56 ohms so that the voltage which would have been thrown across the exciter momentarily would have been 308 volts. This might have been enough to demagnetize an exciter set at 275 volts, although it is thought that the time required to weaken and reverse the exciter magnetism would be greater than the duration of the induced generator field current at its maximum negative value. Another factor preventing demagnetization of the exciter is that the field current of the high pressure unit would have to be negligible or also reversed at the same time, since the net current in the common exciter is the sum of the instantaneous field currents in the high and low pressure units.

In each case when the field switch was closed, the field current instantly started to build up in the right direction, the armature currents returned to their normal values in about 5 seconds, the station voltage recovered to almost normal in the same length of time, and in about 20 seconds the station voltage had completely recovered. In each case the machine recovered synchronous speed in less than 2 seconds.

As a result of these tests and of a number of questionnaires sent to operating companies and manufacturers, fairly definite conclusions may be drawn. It is felt that when for any cause the field switch of a loaded alternator is opened unexpectedly, the usual practise of taking the unit off the system, re-exciting and resynchronizing it, is unnecessary and that considerable time in restoring normal operations without severe disturbance to the system is obtained by closing the field switch as soon as possible. The generator need not be removed from the bus at any time except in rather remote cases. It is recognized that different types of generators behave differently when the excitation is cut off, and that the older units having low resistance field windings and operating with 125-volt excitation are more erratic than later machines employing 250-volt excitation. It may be safely stated, however, that if the unit is carrying less than three-quarters load, there is no danger in reclosing the field switch. If the unit is carrying more than three-quarters load it will be prudent to lower the governor before reclosing the field switch. Also, if the bus voltage has dropped to 60 per cent of normal it is considered advisable to cut off the generator so as not to increase the tendency of other generators dropping out of step. However, such a reduction in voltage due to an open field is unlikely on large systems.

Owing to its reactance, it is impossible for the rotor field to increase to full strength immediately; it also follows that due to a weaker magnetic coupling it is impossible for the rotor to change speed instantly, and there can be no shock such as occurs when a machine is paralleled out of phase. To insure proper polarity when closing the field switch, the exciter, if self-excited, should always be operated above the knee of its saturation curve. The belief that while the switch is open excessive current which would prove injurious might be induced in the field winding was not borne out by the observed values of current.

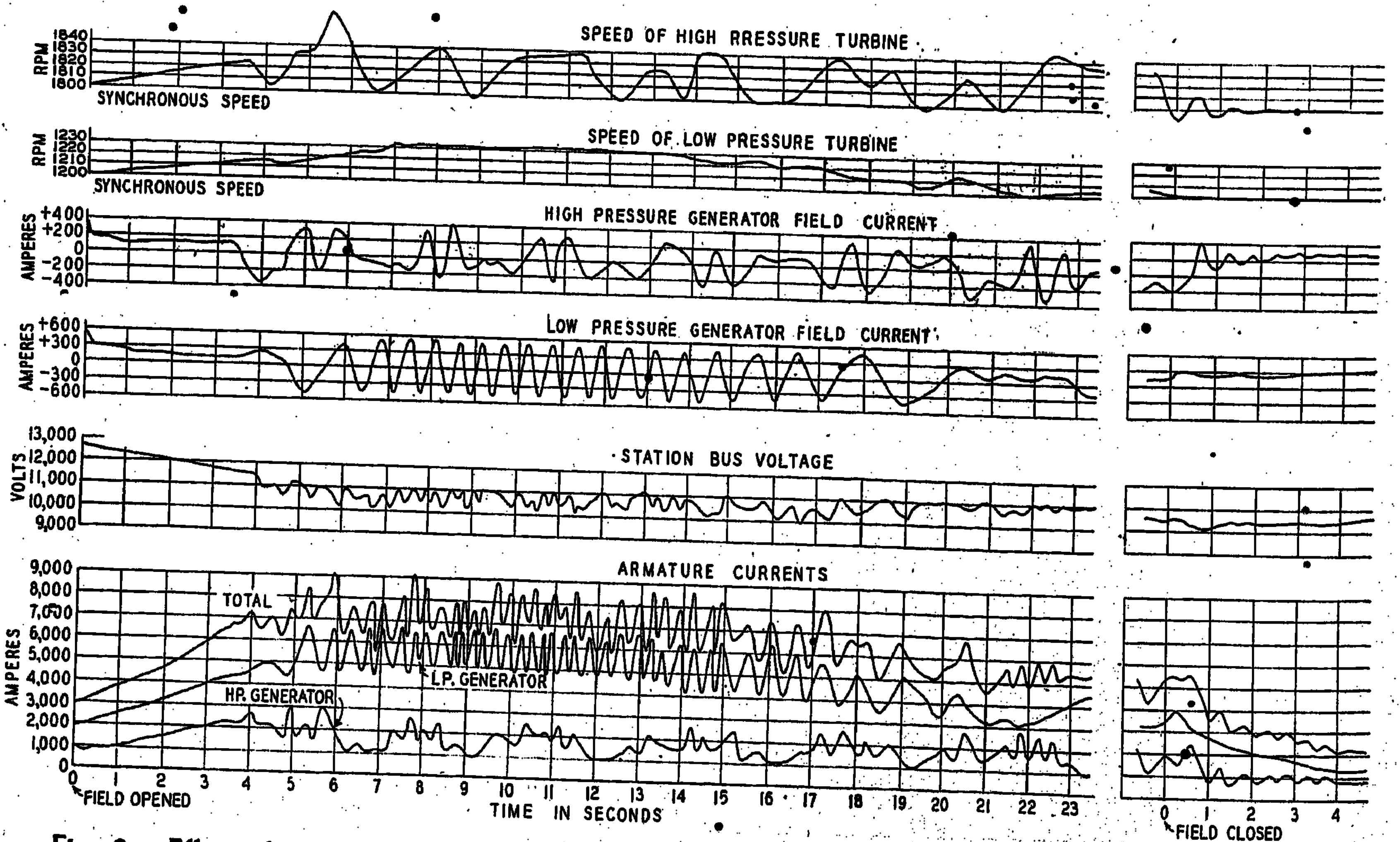

Fig. 2. Effect of opening and later reclosing the field switch of unit No. 2 at Crawford Ave. station. The machine was carrying 50,000 kw. at 80 per cent power factor when field was opened

# Hinged Wooden Arms Used on Osage-Rivermines Line

**Extra insulation was obtained on this important link of the Union Electric Light and Power Company transmission system by the use of wood crossarms. By hinging the arms to the steel tower structures, arm and tower stresses were reduced materially; consequently tower weights and line costs were lowered accordingly. Details of these and other major features of this unusual line are given in this article.**

By

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HINGED WOOD CROSSARMS have been adopted for the 119.5-mile power transmission line which connects from the Osage hydroelectric development to the Rivermines substation of the Union Electric Light and Power Company (Mo.). Wood arms were selected because service requirements demanded better performance than that usually obtained with double circuit lines supported by all steel structures. These arms were hinged to the steel structures because of cost considerations: with such construction the forces applied to both arms and towers when conductor wires break are much lower than with rigid arm towers; consequently the cost of such towers is from 15 to 20 per cent lower than for rigid arm towers. Tests showed that with these arms and 11 insulator units, the line insulation is equivalent to that obtained with from 17 to 23 units on steel arms. Design of the arm involved the development of a suitable clamp for the tension member, details of which are given later.

The Osage hydroelectric development[1,2] (for numbered references see bibliography) is situated near the geographic center of the State of Missouri and about 140 miles west of the load center of the Union Electric Light and Power Company. Initial development includes six 33,500-hp. generating units. Two 132-kv. transmission lines were built to deliver the plant output to the existing transmission system which in a general way follows the Mississippi River from Keokuk, Iowa, on the north to the lead mining district near Rivermines, Missouri, on the south. One of the new lines is a single-circuit wood-frame line 135.5 miles long reaching from Osage to the Page Avenue substation in the outskirts of St. Louis; the other is the steel tower line with hinged wood crossarms, which is the subject of this article.

Important data of the Osage-Rivermines line are summarized in Table I. Each of the two circuits is designed to handle the output of two hydroelectric generators each rated 23,888 kva. at 0.9 power factor, and 60 deg. cent. (27,500 kva. at unity power factor, and 80 deg. cent.) through a single bank of transformers. Later, the power station may be equipped with a main bus, whereupon either circuit may be called upon to deliver the full air-blast bank rating of 60,000 kva.

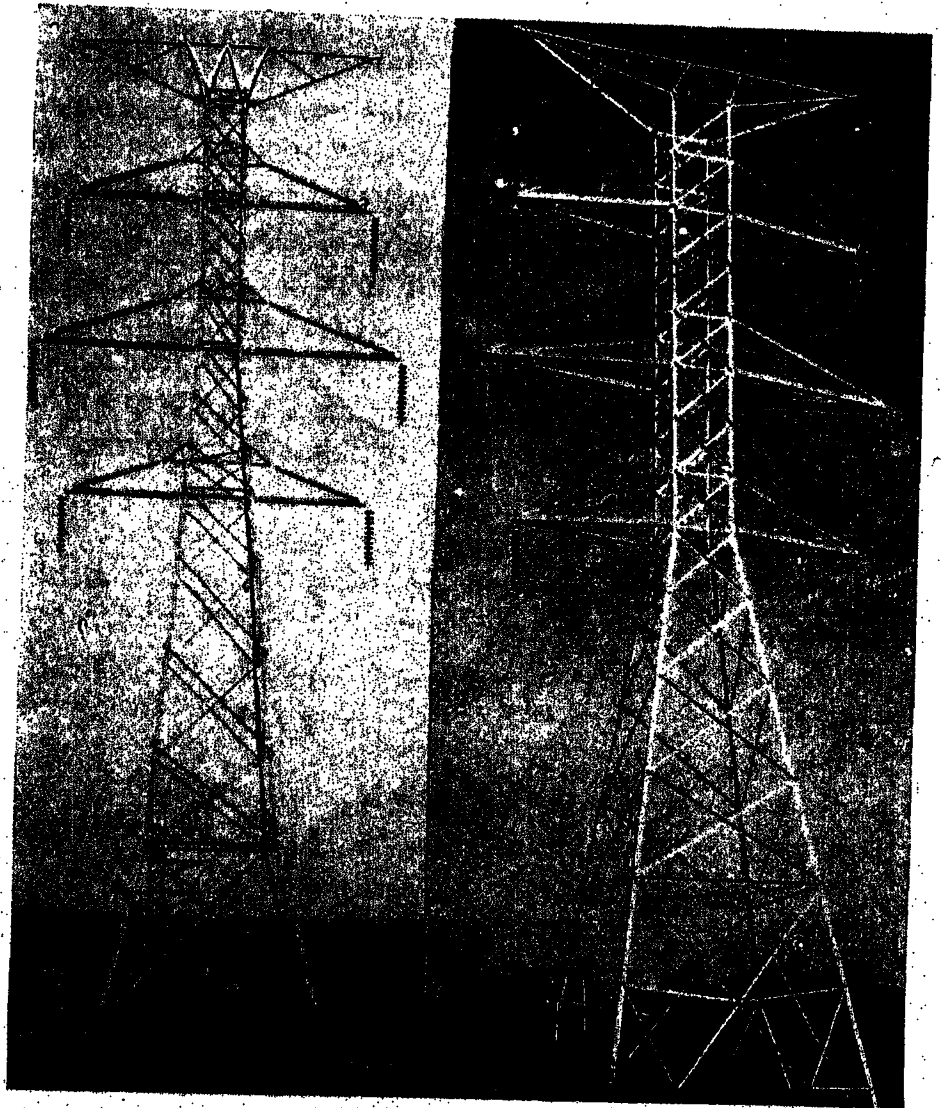

Fig. 1. Typical tower with hinged wood arms (left) and (right) tower with rigid wood arms as used at angles in the line and at certain long spans

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Written especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

Energy transmitted annually will vary between 50 and 250 million kw-hr. per circuit.

To make the best use of the hydroelectric development, it will be operated as a peak cut-off plant replacing equivalent steam capacity in St. Louis. Such a procedure can be justified only on the basis of equal reliability. At a distance of 120 miles in a country with Missouri's record for sleet and lightning, this is an exacting requirement but was accepted as the basic specification for the Osage-Rivermines line.

A double-circuit steel tower line had been considered as being most suitable from a cost standpoint; yet it was felt that the service required fewer outages, particularly those involving both circuits, than the records of this type of construction would indicate as probable for a 120-mile line. More insulation seemed to be the principal need and it was suggested that some of the advantages of wood pole line construction might be realized by using wood crossarms.[3,4,5,6]

A preliminary study of the application of wood insulation to the crossarm assembly showed that it would involve a marked increase in cost as compared with steel unless some compensating measures were adopted. Aside from an arbitrary reduction in the factor of safety, which was considered with some misgivings, the only course available was to reduce the forces applied to the arms and tower when conductor wires break. The problem of reducing the forces from broken wires has received quite a bit of attention from transmission engineers and has resulted in the development of a number of slip clamps as well as in the hinged crossarm. (The metal hinged arm is not new.[7] Its operation was demonstrated publicly in this country in 1927 and the Public Service Company of Northern Illinois has 3 miles of line with hinged steel arms built in 1928.)

For the foregoing reasons, therefore, and because of its adaptability to the wood insulation idea, hinged arm construction finally was adopted. The arms are hinged at the tower end on an axis inclined away from the tower at the top by an angle of 20 deg. This inclination of the axis causes the swinging movement to be restrained by the weight of the arm and by any vertical load it may be carrying, so that normally the arm acts in the same way as though it were rigid. If a wire should break, the arm swings away from the broken span reducing both torsional and overturning moments.

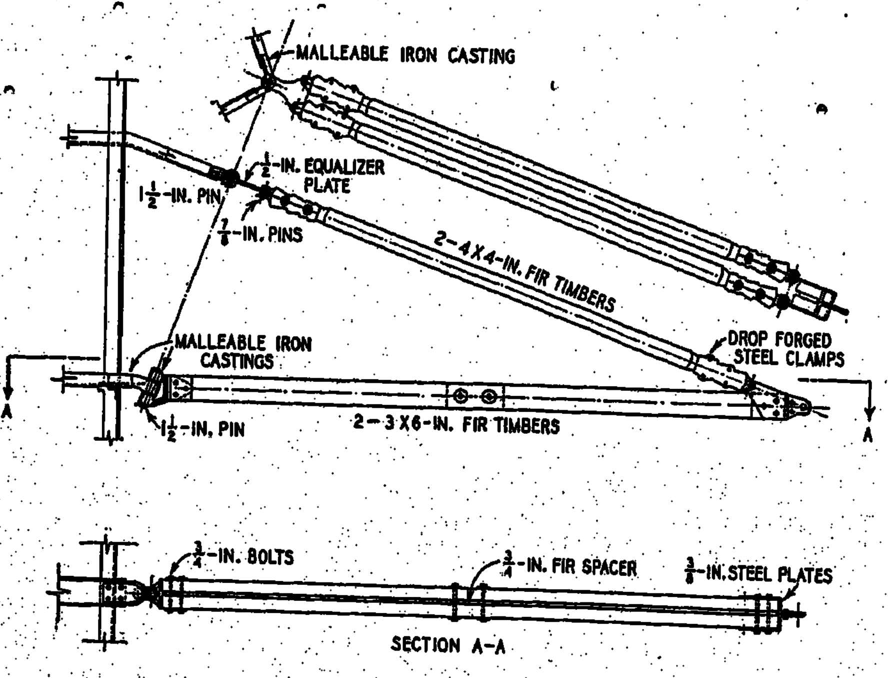


Fig. 2. Details of hinged wood arm

## DESIGN OF HINGED WOOD ARMS

Construction of the arm is quite simple, consisting as it does of a pair of tension members and a compression member pinned together at the outer end. (See Fig. 2.) Tension members are in duplicate while the compression member is built up from two similar timbers bolted together; this is to minimize the effect of any shattering from lightning. With either tension member or either half of the compression element put out of commission, the assembly still is strong enough to carry any normal loads likely to occur.

Untreated Douglas fir was chosen as the material for the arms because it offered certain advantages in durability, strength, availability, economy, and ease of working. Some of the more important mechanical properties of the grade of wood selected are approximately as follows:

| | |
|---|---|
| Tensile strength | 7,000 lb. per sq. in. |
| Shear strength parallel to grain | 900 lb. per sq. in. |
| Compressive strength perpendicular to grain | 500 lb. per sq. in. |
| Compressive strength parallel to grain | 3,500 lb. per sq. in. |

No extraordinary difficulties were encountered in the design of the compression member. The tension member, however, offered a rather serious problem because of

**Table I—Pertinent Features of Osage-Rivermines Line**

**Length.** 119.5 miles (631,014 ft.) all on steel towers.

**Circuits.** 2—132-kv., 3-phase, 60-cycle.

**Conductors.** 6—250,000-cir. mil, 19-strand, copper.

**Ground wires.** 2—7/16-in., 7-strand, Siemens-Martin steel, galvanized.

**Standard tower height.** To peak 91 ft.; to bottom conductor 42 ft.-4 in.

**Standard tower extensions.** Single or multiple leg extensions, 4 ft. and 8 ft. Body extensions, 16 ft. Footing extensions, 2 ft.

**Standard tower wire spacings.** HORIZONTAL BETWEEN CIRCUITS: ground wires, 29 ft.; conductors, top 29 ft., middle 35 ft., bottom, 29 ft. VERTICAL: between conductors 14 ft.; between ground wires and top conductors 20 ft.-8 in.

**Length of span.** Average 827 ft., normal 700 ft., maximum 2,208 ft.

**Standard tower loading.** Equivalent span for vertical loading, 1,500 ft. Equivalent span for transverse loading 1,100 ft. Wire loads ½ in. radial ice and wind pressure of 8 lb. per sq. in.; any two wires broken; factor of safety against failure 1.5.

**Wire tensions (normal span).** CONDUCTOR: 2,450 lb. at no ice, no wind, 60 deg. fahr.; 5,500 lb. at ½ in. ice, 8 lb. per sq. in. wind pressure, 0 deg. fahr. GROUND WIRE: 1,300 lb. at no ice, no wind, 60 deg. fahr.; 4,250 lb. at ½ in. ice, 8 lb. per sq. in. wind pressure, 0 deg. fahr.

**Standard tower weight.** Tower proper, 7,600 lb.; hinged arms 2,100 lb. (timbers, 1,000 and metal parts, 1,100); footings 1,200 lb.; total, 10,900 lb.

**Standard conductor arms.** Hinged on axis tilted 20 deg. from vertical. Duplicate tension members, 4x4-in. fir with forged steel clamps. Compression member, 2—3x6-in. fir timbers, blocked and bolted together. Wood insulation varies from 6.3 to 10.3 ft.

**Insulation.** On wood arms, 11-unit suspension strings, 13-unit strain strings. On steel arms, 16-unit strings. No arcing horns on initial installation.

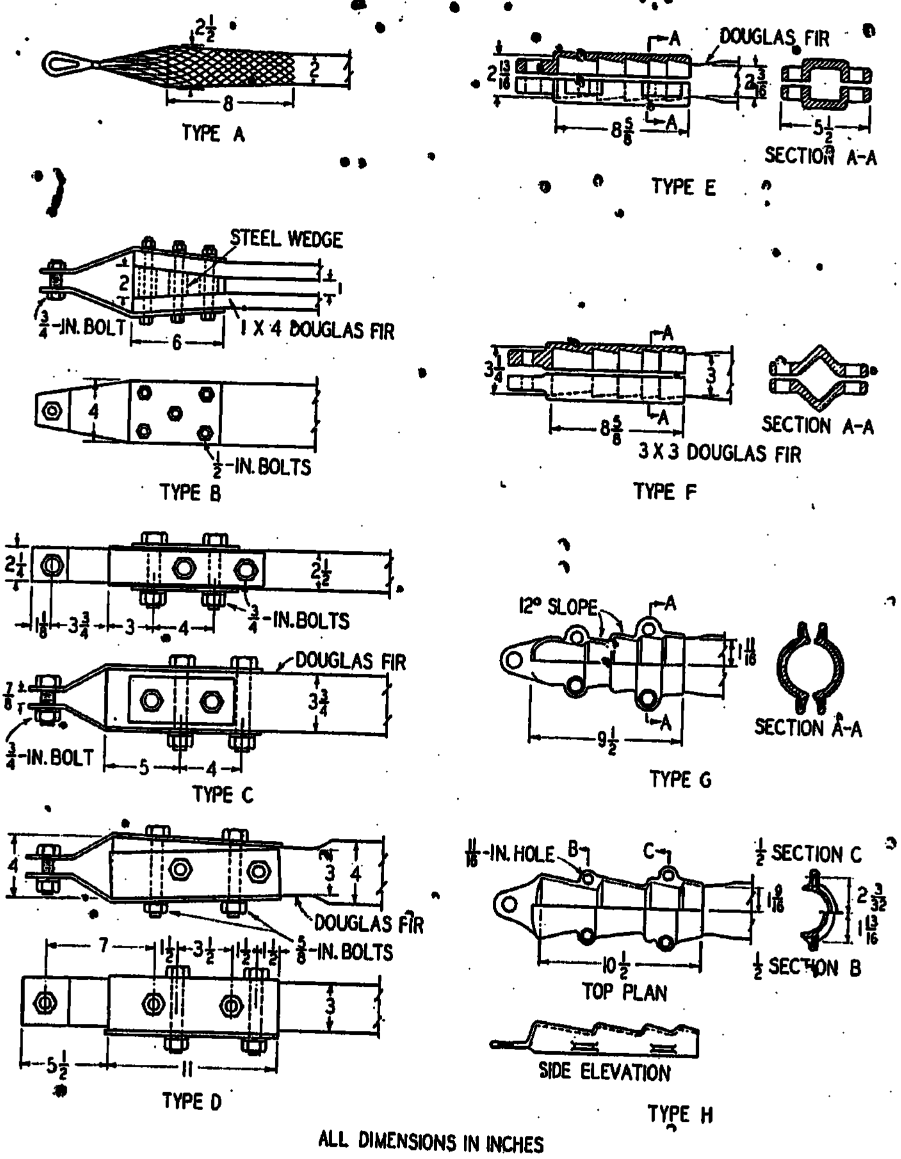


**Fig. 3. General types of wood strain insulator fittings tested; type H finally was selected**

See Figs. 5 and 6 for general theory and design of wedge type clamps applying to all of the above fittings

the difficulty of making an attachment to a wood member so as to develop any great portion of the load which the wood is capable of sustaining in tension. This is because wood is comparatively weak in shear parallel to the grain and in compression perpendicular to the grain.

With these facts in mind, an extensive series of tests was conducted to develop a fitting suitable for the tension member. Some of the more general types of fittings tested are shown in Fig. 3. Type *H* fitting finally was adopted, it having been found to possess the following advantages:

1. Tendency of the wood to decay should be comparatively small as the clamp encloses almost the entire member, at the same time providing ventilation, and as there are no bolts through the wood.
2. Probability of the wood splitting due either to lightning strokes or to seasoning is eliminated largely by the clamping action of the fitting.
3. The metal is in close contact with the wood at all times; hence, the device should be free from leakage current troubles.
4. Strength of the attachment is not affected materially by a small amount of shrinkage in the wood because the taper permits a corresponding slippage which in turn readjusts the clamp. Experience has indicated, however, that if the wood is put up green and allowed to season in place, the bolts should be tightened after the wood has taken its initial shrinkage.
5. Drop-forged hot galvanized steel clamps of this type with copper bearing surfaces provide the required strength and length of life, with a high degree of reliability.

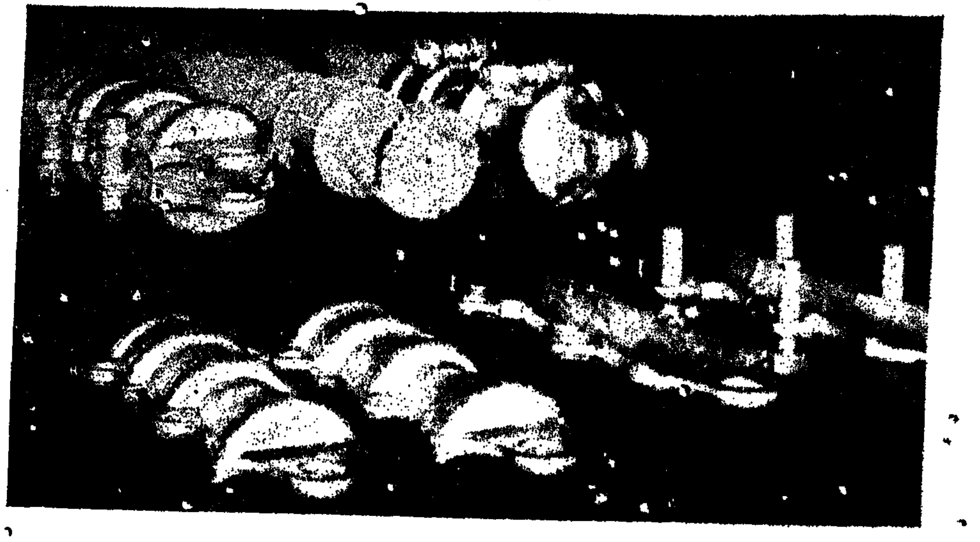


**Fig. 4. Tension members of hinged wood arms showing method of applying clamps**

Two of the fittings are clamped onto each end of a 4x4-in. timber to make up the complete tension member (the ends of the timber of course being turned down to the proper shape). (Fig. 4.) In the wedge-like operation of this fitting the tensile load is translated into compression and shear stresses, the ratio between the two being controlled by the angles of the sloping surfaces and their coefficients of friction (see Figs. 5 and 6). By making the steps near the end of the stick successively smaller in diameter, each step tends to work on a different set of fibers with the result that the load is well distributed throughout the timber.

Ultimate breaking strength of the member with this type of fitting varies from about 35,000 lb. for a clamp having galvanized wedge surfaces, to about 50,000 lb. for a clamp having rough wedge surfaces. This difference is due to the fact that, for a given pull, the corresponding compression load on the wood varies inversely as the tangent of the sum of the friction angle and the angle of inclination of the wedge surfaces (see Figs. 5 and 6).

The compression member consists of two 3x6-in. timbers bolted together with ½-in spacers at the midpoint or third points, depending upon the length of the arm. (Figs. 2 and 7.) The end fittings were designed to bring as much of the compression load as possible directly upon the ends of the timbers rather than on the bolts the primary function of which is to hold the assembly together rather than transmit load. The fitting at the outer end is made up from forged steel plates which in addition to applying the load to the compression element, provide places of attachment for the tension members and the suspension insulators. At the tower end the compression timbers are seated in a malleable iron casting which forms the rotating part of the hinge.

Compression and tension elements were assembled individually in the factory; these were pinned together in the field, then hoisted up the tower as a complete arm and attached by inserting the two hinge pins. This operation proved to be quite simple as did the stringing of conductors, the latter operation being carried out in quite the same manner as on rigid arm construction.

During the rather extensive tests carried out in connection with the design of these arms, certain important details appeared as being fundamental to the success of an undertaking such as this. These are listed in the hope that they may prove helpful in any similar project in the future; they are briefly:

1. Rigid purchase specifications should be set up and repeated inspection made of each piece of timber during process of manufacture.

2. Proper attention must be given to the method of drying, whether done in kilns under special specifications or by other means.

3. If any form of treatment be used, care must be taken that the treatment does not lower the electrical resistance of the wood unnecessarily nor weaken it mechanically due to the high temperature sometimes employed.

4. Clamps and fittings attached to the timber must contain adequate provision for shrinkage across the grain and should be fitted accurately so as to distribute the stresses properly.

5. Thin sections in timbers exposed to the weather should not be used because of the unavoidable checking which becomes more serious with such sections, and the greater rate of depreciation due to the increase in exposed area.

6. Careful design can reduce the difficulties due to splitting by lightning when attention is given to the location of or possible reduction in the number of bolts through the timber. At points where electric current is likely to leave the metal and pass into the wood, the stress can be distributed somewhat by slightly flaring the metal away from the wood, rather than concentrating such stress upon a single line at sharp edges.

7. Normal continuous working stresses should be low. In designs providing for heavy ice loading this will be obtained automatically when ample strength is provided for the ice load; also in designs which provide duplication of parts to guard against the loss of such members due to lightning, similar low stresses will be obtained for normal loading.

In a relative evaluation of the above items, the first and the last probably are of greatest importance.

In this day of almost universal treatment of timbers in permanent outdoor structures, it may be surprising to some that the wood arms used in this line were not treated in any way. Treatment with creosote oil admittedly lengthens the serviceable life of wood and probably cuts down the amount of checking to a certain extent; but it had two important disadvantages in this application: it cuts down the lightning flashover voltage, definitely if slightly; and due to the lubricating qualities of the oil, it upsets the balance of design in the friction clamp on the tension member. Furthermore, as stated previously, unless extreme care is taken, there is a possibility of reducing the mechanical strength of some types of wood by the temperatures attained in treating.

It having been decided for these reasons to use untreated wood, the choice quite naturally fell to Douglas fir as mentioned previously, the highest commercial grade of which (dense superstructural) was selected. As seasoned timber of this grade is not available in any great quantity, for this job all of it was specially cut from green logs. This meant that most of the shrinkage took place after the arms were on the towers. This was anticipated and a general tightening of all bolts accordingly was scheduled for the end of the first summer season. Checking was aggravated to some extent by exposure to the intense summer heat without a preliminary seasoning.

The principal risk assumed by the substitution of wood for steel in a crossarm is the chance of shattering from lightning. The exterior of the tension members used in the electrical tests (described later) was quite badly splintered by the repeated flashovers; it is probable that the damage from real lightning would have been much worse. An attempt has been made to minimize these effects, however, by proper design of the metal fittings and provision is also made for attaching arcing horns if they should prove advisable; but the main reliance is placed in the overhead ground wires, in the duplication of the tension members, and in the two part construction of the compression element of the arm.

## INSULATION TESTS ON THE WOOD ARMS

As a check on the increase in insulation due to the wood arms, part of a tower was set up in the Trafford high voltage laboratory and the minimum surge to flash over a string of eleven 5.75x10-in. insulator units on each arm was determined. The measurements with the equivalent insulation in number of similar insulator units on steel arms were:

| | | |
|---|---|---|
| Top arm | 1,350 kv. (crest) | 17 units |
| Middle arm | 1,720 kv. (crest) | 22-23 units |
| Bottom arm | 1,550 kv. (crest) | 20 units |

Surges used for the tests rose to maximum value in 1.5 microsec. and fell to half voltage in 60 microsec. Flashovers for minimum surges had a time lag of about 40 microsec.

The arc from the top conductor jumped to the wood tension member of the middle arm, and followed this member to the tower; arcs from the middle and bottom conductors flashed up the insulator strings and to the tower, sometimes by way of the tension members and

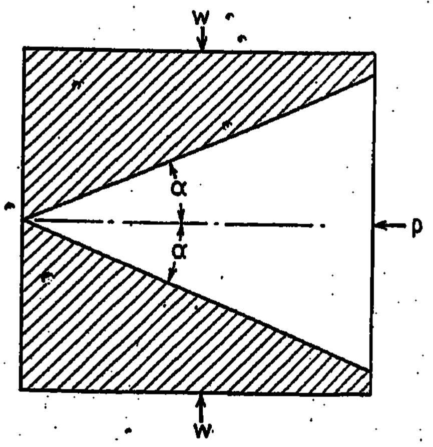


**Fig. 5. Friction clamp theory for all fittings shown in Fig. 3**

$w$ = Force exerted by resisting body
$\alpha$ = Angle of inclination of the sides of the wedge
$\phi$ = Angle of friction
$p$ = Force required to push the wedge

$$p = 2\,w \tan(\alpha + \phi) \qquad (1)$$

Similarly, the force required to withdraw the wedge is given by:

$$-p = 2\,w \tan(\alpha - \phi) \qquad (2)$$

From eq. 1 may be seen that for a given value of $p$, load $w$ decreases when tan $(\alpha + \phi)$ increases. In cases where it is desirable to keep $w$ as small as possible and it is not feasible to increase angle $\alpha$, the desired result may be obtained by employing an abrasive on the bearing surface of the wedge, thus increasing angle $\phi$.

Wedge will not keep itself in position if $\alpha$ is greater than $\phi$. This fact is worthy of consideration where the wedge is subjected to varying loads and is made of a material whose maximum allowable stress depends greatly upon the duration of the stress. In applications of this nature, $\alpha$ should be greater than $\phi$ in order that the wedge be only lightly stressed except during times of heavy loading.

sometimes by way of the compression members. Apparently enough variation existed in the resistance of the timbers to offset occasionally their difference in length.

To check the efficiency of the configuration from an insulation standpoint, measurements were made with varying insulator string lengths, crossarm lengths, and with and without adjacent crossarms. Principal criticism which developed from these experiments was to the effect that quite an appreciable gain in insulation for the top conductor could have been realized if the space between the top and middle arms had been increased by a foot or more.

Insulation of the line with eleven insulator units on wood crossarms is considerably higher than that of the substation equipment at the terminals. Therefore to assist the lightning arresters in protecting the substation apparatus from the hazard of lightning surges coming in from the line, the terminal stations are equipped with fused gaps. Owing to the difference in the equipment at the two ends of the line, the power station gaps are set at 40 in. and the receiving station gaps at 37 in.

## EFFECT OF WOOD ARM CONSTRUCTION ON TOWER DESIGN

Standard suspension towers with hinged wood arms do not appear greatly different from conventional towers (see Fig. 1) although the 20-ft. base and 4-ft. cage section used in this line are somewhat smaller than would be expected for towers 91-ft. in height. Ground wire supports are unusually prominent because of the location of the two ground wires, one being placed directly over the top conductor of each circuit with a vertical separation of 21 ft. With this arrangement, the ground wires should be well situated to intercept direct lightning strokes at midspan and divert them to the tower without side flashes to the conductor.[8] The increased moments due to this ground wire arrangement made it advisable to carry the batter of the legs up to the middle arm.

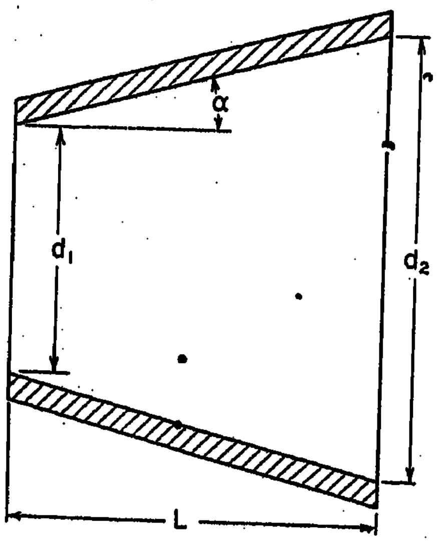


Fig. 6. Friction clamp design for all fittings of Fig. 3

$\alpha$ = Angle of inclination of wedge
$\phi_1$ = Friction angle, wood on friction surface of clamp
$\phi_2$ = Friction angle, wood on wood
$S_t$ = Ultimate unit tensile strength of wood
$S_c$ = Maximum unit compressive strength of wood, perpendicular to wedge surface
$S_s$ = Maximum unit shear strength of wood parallel to the grain

For a balanced design

$p$ = Tensile strength = compressive strength = shear strength, or

$p$ = (Cross section at front end of clamp) $(S_t)$
= $(S_c)(\text{Cos }\alpha)$(surface area of wedges) $\tan(\alpha + \phi_1)$
= Shear area of base of wedge $S_s$ + (Compressive load perpendicular to shear plane) $\tan \phi_2$

Practical considerations as to the size of the wood member to be employed might make a balanced design undesirable

A comparison between the tower design used in hinged arm construction and that which would have been required for a rigid arm line may be of some interest. It is quite apparent that towers for use with hinged arms involved the setting up of load assumptions different in some respects from those used in conventional rigid arm design. To show what these differences were and how they affected the tower design, a comparison has been developed between the hinged arm tower actually used on the Osage-Rivermines line and a tower with rigid wood arms otherwise structurally and electrically equivalent. This comparison is shown in Table II. Load assumptions used in this comparison represent unit stresses in the structures up to the elastic limit of the material beyond which it is assumed that tower failure would occur.

Vertical and lateral loads are the same for both types of construction, but in the case of broken wires the movement of the hinged arms will change the point of application of some of the loads. This introduces an unbalance in these loads which is not encountered in rigid arm design. However, the principal difference in loading rests in the magnitude and location of the longitudinal forces resulting from broken wires.

In rigid arm towers the longitudinal load generally adopted as a design basis is of the type indicated in Table II. For hinged arms the loads had to be based upon existing knowledge of hinged arm operation which was not very extensive. Lack of experience in this respect is reflected in the three more or less overlapping load assumptions (see Table II). With the accumulation of test data and operating experience, however, it is probable that a single longitudinal load assumption will be developed as in the case of rigid arm towers.

Effect of the hinged arm when wires break is to cause (1) a shift in the application of the longitudinal load to a point nearer the center of the tower, and (2) a reduction in the magnitude of this load to one-half its original value (except for the effect of impact at the end of the arm's swing which was assumed to build up to the original tension for an instant only). In case 3, where the impact forces of a breaking wire are superposed upon the forces resulting from a previously broken wire, the factor of safety was reduced as the result of a discussion as to whether or not case 3 was justified at all. These combined loadings were not applied lower than the first panel of the tower below the bottom crossarm because it was considered that the impact stresses would not extend beyond this point, but would be absorbed in the bolted connections above. Case 3 was found to be controlling in that part of the tower to which it was applied.

Weight distribution for the tower actually adopted for hinged arm service on this line is shown in Table I. Total weight of the tower (10,900 lb.) is approximately

2,000 lb. less than the estimated weight of an equivalent tower with rigid wood arms. As a result the cost of the hinged arm tower is estimated to be from 15 to 20 per cent less than for the rigid arm tower with which it has been compared. However, at certain locations in the line, namely, at angles and for certain long spans, hinged arms could not be used; for these cases rigid arms were required. In order that the insulation level might be maintained at these points, rigid wood arm assemblies were devised, the tension and compression elements being quite similar to those of the hinged assemblies. (See Figs. 1 and 8.)

### OTHER FACTORS OF TOWER DESIGN

One disadvantage of a double-circuit line in a "lightning" country is that construction economy tends to force the use of higher towers with consequent increased lightning exposure. This was particularly true in the case of the Osage-Rivermines line where the sharply rolling terrain continually offered opportunities for eliminating towers by the liberal use of tower extensions. Even with the exercise of some restraint in this respect, extensions varying in height from 4 to 16 ft. were justified for 40 per cent of the towers; this was on the basis that the saving in construction cost could not be offset by an intangible improvement in operation which might result from using more towers and shorter spans, and which in view of the high insulation of the line would be expected to be quite small anyway. As a concession to the electrical phase of this problem, however, the use of 16-ft. extensions on exposed ridges was limited to those locations where their application would not raise the conductors higher than at either of the adjacent towers.

### Table II—Loading Comparison Between Rigid Arm and Hinged Arm Towers

**RIGID ARM DESIGN**

**Vertical loads.** Weight of insulators and wires with ½ in. radial ice, for 1,500-ft. spans, multiplied by 1.5; dead load of tower, multiplied by 1.5.

**Lateral loads.** Wind load of 8 lb. per sq. ft. acting on wires with ½ in. radial ice, for 1,100-ft. spans, multiplied by 1.5; wind load of 15 lb. per sq. ft. on 1.5 times the area of material in one face of tower, multiplied by 1.5.

**Longitudinal loads.** Unbalanced load of any two broken wires at full load of 5,630 lb. for conductors and 4,400 lb. for ground wires, multiplied by 1.5.

**HINGED ARM DESIGN**

**Vertical and lateral loads.** Same as for rigid arm design.

**Longitudinal loads.** CASE 1. Unbalanced load of any one wire broken at full load but reduced to half tension by the arm swinging 90 deg. into the direction of the line; this loading combined with an impact load of equal amount (5,630 for conductors, 4,400 lb. for ground wires) multiplied by 1.5.

CASE 2. Unbalanced load of any two wires broken at full load but reduced to half tension by the arm swinging 90 deg. into the line (2,815 lb. for conductors and 2,200 lb. for ground wires) multiplied by 1.5.

CASE 3. Unbalanced load of any one wire broken at full load but reduced to half tension by the arm swinging 90 deg. into the line (2,815 lb. for a conductor or 2,200 lb. for a ground wire) multiplied by 1.5; this load combined with the unbalanced load of any one wire broken at full load but reduced to half tension by the arm swinging 90 deg. into the direction of the line, and an impact load of equal amount, (5,630 lb. for a conductor *or* 4,400 lb. for a ground wire) multiplied by 1.25. The effect of these loads should be considered only down to first panel point below bottom arms.

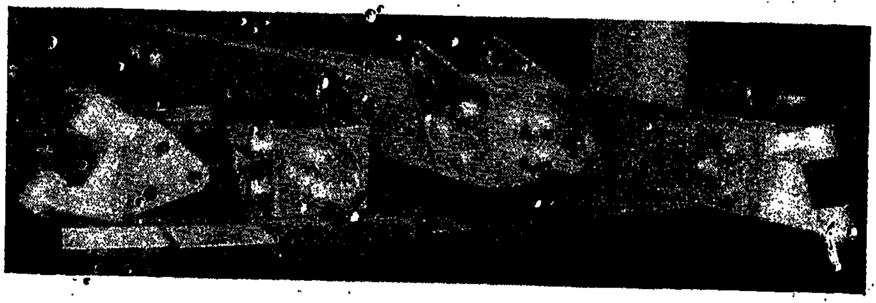


Fig. 7. Compression members of hinged wood arms showing method of applying clamps

Standard tower footing consisted of the familiar pyramidal framework resting on a square grillage. The only interesting departure from usual practise was suggested by the unevenness of the ground at the tower site. Sidehill leg extensions of 4 ft. or more had been provided for about 12 per cent of the towers, but many instances were found where a single leg extension of 2 ft. would be convenient. This need was met by designing a footing which projects 2 ft. out of the ground but which otherwise is similar to the standard anchor. The increased weight for one footing was only about 60 lb. and its advantages were many: it saved laborious cut and fill in material that was largely rock, and it permitted the establishing of higher grades with consequent gain in span lengths. Interchangeability of the two types of footings permitted the more general use of standard towers without the confusing inconveniences of substituting special leg and bracing material. More than half the towers in the line have one or more of these high footings.

### TOWER GROUND RESISTANCE

In view of the close relation between tower ground impedance and line performance under lightning conditions, the ground resistance of every tower was measured and recorded as an aid to analyzing any subsequent lightning outages. With ground wires detached, measurements were made by means of a direct reading megger ground resistance tester with a three-range scale (0 to 3 ohms, 0 to 30 ohms, and 0 to 300 ohms). Four readings were taken at each tower and the average taken as the tower ground resistance; each reading was taken between the tower base and two ¾-in. tool steel auxiliary ground rods driven into the earth to a depth of 3 ft. Positions of the auxiliary grounds were determined by tests. (See Fig. 9.) At many of the towers it was necessary to probe over a considerable area in order to find a place where the rods could be driven down 3 ft.; however, the arrangement of Fig. 9 was followed as closely as possible.

Results of these tests are shown in Fig. 10 from which may be seen that the footing resistances varied from less than 1 ohm up to 56 ohms, the average for all towers being 6.9 ohms. The measurements were made in an extremely dry season and soon after the towers were erected so that the earth had not settled around the

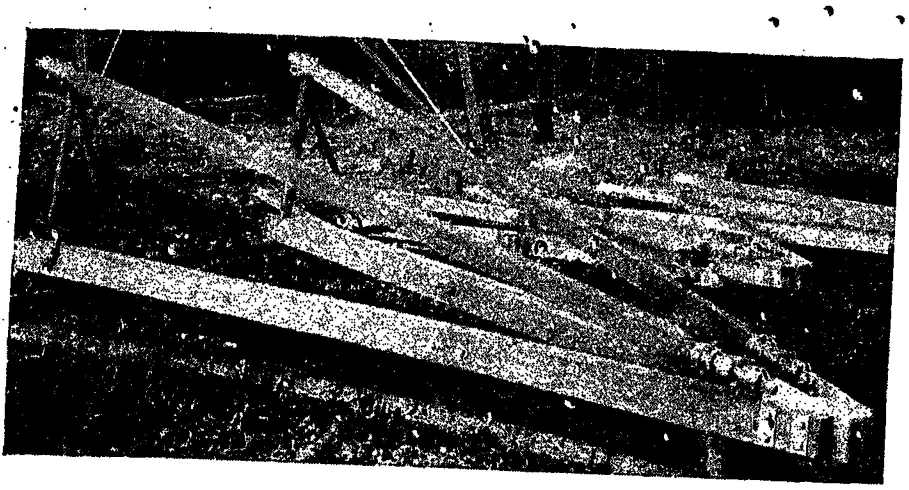


Fig. 8. Rigid wood arms as used at angles in the line and at certain long spans

footings. It is probable that after a few rains the earth will settle more compactly around the footings and that the ground resistances then will be somewhat lower.

Analysis of the curves in Fig. 10 show that 629 towers, or 83 per cent, of a total of 760 have ground resistances of 10 ohms or less. An examination of the 131 towers having resistances above 10 ohms brought out the fact that 46.1 per cent of these are set in sandstone, 37.5 per cent in limestone containing a large amount of chert, 14.1 per cent in limestone free from chert, and 2.3 per cent in sand and gravel. Approximately 5 per cent of the towers have resistances above 20 ohms, of which 70.5 per cent are set in sandstone, 20.6 per cent in limestone containing a large amount of chert, and 8.9 per cent in limestone free from chert.

No attempt is being made to lower any of the resistances at the present time because (1) average resistance of the line is low; (2) the high resistances are scattered along the line with not more than four consecutive towers having resistances above 10 ohms; and (3) the cost of lowering the high resistances would be excessive due to the fact that the footings on these towers are set in solid rock. Records of the locations of all flashovers will be kept and if it is found that the flashovers tend to concentrate on towers having high ground resistance, an attempt will be made to lower the resistance at these towers, or to provide some other form of protection.

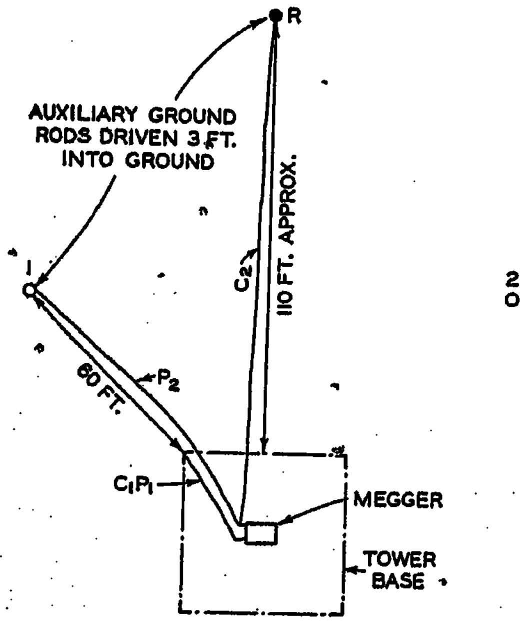
Some additional data on the ground return path was obtained from a test made primarily for measuring the inductive effects on neighboring communication circuits. One 250,000-cir. mil copper conductor was grounded 85 miles from the power station, and energized from one terminal of a generator with its neutral grounded through a 4-ohm resistor. Readings taken on this test were: generator potential to neutral, 3,720 volts; current, 31 amperes; power 48 kw. (frequency 60 cycles).

From these data the resistance of the ground return path was computed to be 26 ohms, and the 60-cycle reactance of the circuit, 109 ohms. Based upon this reactance, the distance from the conductor to the center of the return path was computed to be 720 ft. The low value for the depth of the return probably is due to the small current used in the test.

### Line Laid Out from Aerial Survey

In conclusion, a word about the preliminary survey of the line location might not be amiss. This was unusual in that it was carried out entirely with the company's own aerial equipment and personnel. Planes and cameras are becoming available so generally that survey parties can be organized as readily for work in the air as on the ground.

The aerial method effected an enormous saving in time and expense in the location of this line. A series of contact prints from photographs taken at a constant height was assembled to give a 400-ft. scale map upon which the line was plotted. Sections of this assembled map were rephotographed for the use of the right-of-way department and an extra set of contact prints from the original films was used for stereoscopic study of the



*R*–Rivermines side of tower
$C_1P_1$–Current and potential lead of megger connected to tower
$C_2$–Auxiliary ground lead to megger current coil
$P_2$–Auxiliary ground lead to megger potential coil
1 and 2–Test positions for $P_2$ with $C_2$ located at *R*
Similar readings were taken on the Osage side of the tower

Fig. 9. Set-up for making tower ground resistance measurements

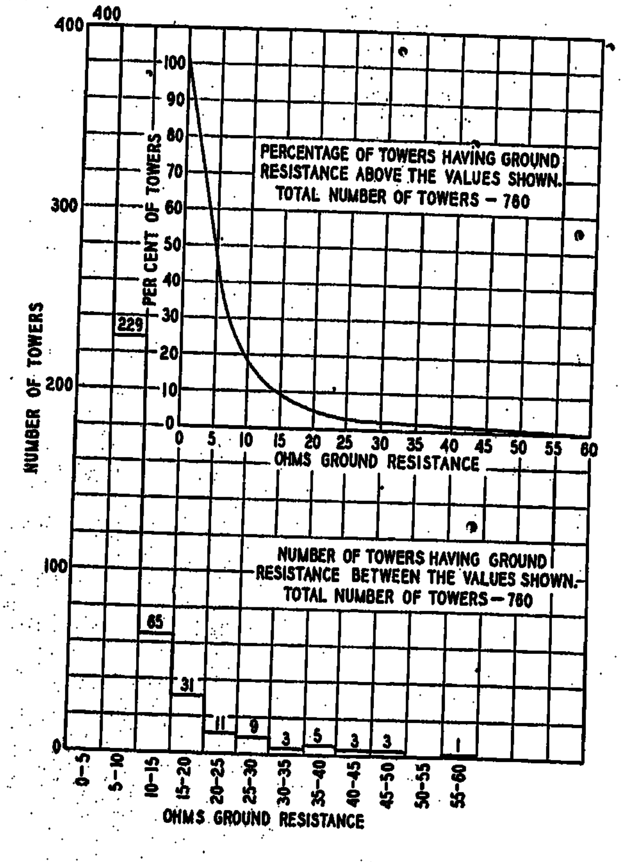


Fig. 10. Results of tower ground resistance tests

topography. Methods and equipment used have been described elsewhere.[9]

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5. IMPULSE INSULATION CHARACTERISTICS OF WOOD POLE LINES, H. L. Melvin. A.I.E.E. TRANS., V. 49, Jan. 1930, p. 21.

6. SURGE CHARACTERISTICS OF INSULATORS AND GAPS, J. J. Torok. A.I.E.E. TRANS., V. 49, July 1930, p. 866.

7. TESTS OF HINGED CROSSARMS. *Elec. World*, V. 90, Nov. 5, 1927, p. 937.

8. TRANSMISSION TOWER DESIGN FOR MAXIMUM LIGHTNING PROTECTION, C. L. Fortescue. *Elec. Jl.*, V. 27, Nov. 1930, p. 640.

9. AERIAL SURVEY FOR TRANSMISSION LINE LOCATION, F. G. Dana. *Civil Engg.*, V. 1, June 1931, p. 249.

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# Propagation Constant of a Transmission Line

**Starting with the logarithmic variation of voltage and current along a transmission line, a derivation of the propagation constant is given in this article, depending only upon the application of Kirchoff's laws and simple hyperbolic trigonometry.**

By
**W. J. CREAMER, JR.**
Associate A.I.E.E.

University of Maine
Orono, Maine

WHEN a transmission line is infinite in length or is terminated in a load equal to its characteristic impedance, the voltage and current at various points along the line vary logarithmically as shown in Fig. 1, and are said to follow the laws of "normal attenuation." Considering, for example, the current wave, we may express the current at any point $d$ miles from the generator end as

$$I = I_0 e^{-\gamma d}$$

where $I_0$ is the current input to the line, $e = 2.7183$, and $\gamma$ is a constant for the particular line at a given frequency and is known as the propagation constant. This constant is a complex number, since there is a change in phase as well as in magnitude of the current as it progresses from the generator end, and is usually expressed as

$$\gamma = \alpha + j\beta$$

$\alpha$ being known as the attenuation constant and $\beta$ as the phase or wavelength constant. In the case of normal attenuation, therefore, the current at any point $d$ miles from the generator is completely expressed by the relation

$$I = I_0 e^{-\gamma d} = I_0 e^{-\alpha d - j\beta d} = I_0 e^{-\alpha d} \underline{/-\beta d}$$

That is, the current is reduced in magnitude by the "attenuation factor" $e^{-\alpha d}$, and shifted in phase by $\beta d$ radians.

The propagation constant of a transmission line usually is developed by means of differential equations, a method which does not recommend itself in an elementary discussion of the laws of normal attenuation. A derivation of this constant which depends only on the application of Kirchoff's laws and simple hyperbolic trigonometry is given below.

Every transmission line has four important linear constants: $R$, the series resistance per loop mile; $L$, the series inductance per loop mile; $C$, the linear capacitance per loop mile; and $G$, the shunt leakance per loop mile. Thus for a short section of line, a mile for example, there will be a series impedance of $Z_1 = R + j\omega L$ ohms, and a shunt impedance of

$$Z_2 = \frac{1}{G + j\omega C}$$

ohms. Let the diagram in Fig. 2 represent three unit lengths of 1 mile each. Calling the current in the first series element $I_0$, that in the second element $I_1$, and that

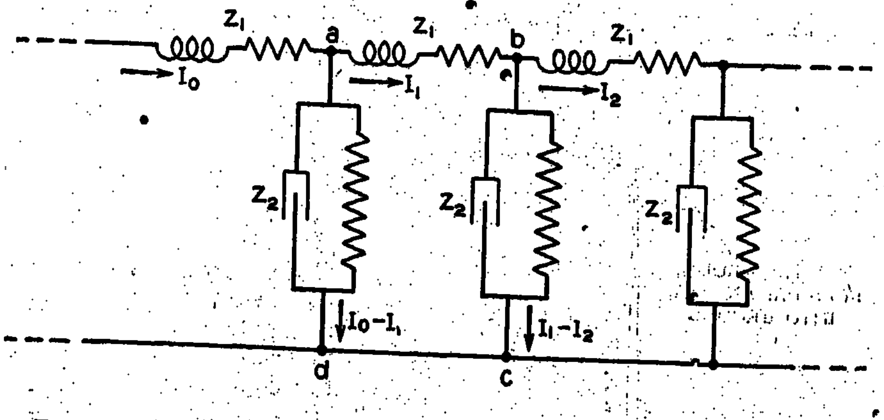

Fig. 2. Recurrent sections representing a transmission line

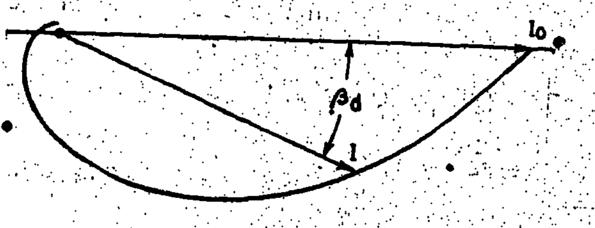

Fig. 1. Logarithmic variation of current with normal attenuation

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Especially written for ELECTRICAL ENGINEERING. Not published in pamphlet form.

in the third $I_2$, we have the current through the first shunt path $I_0 - I_1$, and that through the next shunt path $I_1 - I_2$. Writing Kirchoff's law for electromotive forces in mesh *a-b-c-d*, we have

$$Z_1 I_1 + Z_2 (I_1 - I_2) + Z_2 (I_1 - I_0) = 0 \tag{1}$$

Dividing through by $Z_2 I_1$, we have

$$\frac{Z_1}{Z_2} + 1 - \frac{I_2}{I_1} + 1 - \frac{I_0}{I_1} = 0 \tag{2}$$

which when rearranged becomes

$$\frac{I_2}{I_1} + \frac{I_0}{I_1} = \frac{Z_1}{Z_2} + 2 \tag{3}$$

The two terms on the left of this equation are ratios of the currents in adjacent sections of the line. Now if normal attenuation obtains, it is evident that this current ratio will be the same for any two adjacent sections, and if we call this ratio $e^{\gamma}$, the above equation takes the form

$$e^{\gamma} + e^{-\gamma} - 2 = \frac{Z_1}{Z_2} \tag{4}$$

Extracting the square root of both sides and dividing by 2,

$$\frac{e^{\gamma/2} - e^{-\gamma/2}}{2} = \frac{\sqrt{Z_1/Z_2}}{2} \tag{5}$$

Now the left side of this equation is recognized as the hyperbolic sine of $\gamma/2$, which for small angles is approximately equal to $\gamma/2$; so that the relation in eq. 5 may be written

$$\gamma = \sqrt{(R + j\omega L)(G + j\omega C)} \tag{6}$$

This is the customary expression for the propagation constant of a transmission line.

# Transportation and a Nation's Diet

**Scientific developments have improved natural foods and made possible their wide distribution. This is the eighth article in The Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"**

By
RALPH BUDD

President, Burlington (Ry.) Lines

AMONG the many changes which have taken place in the living conditions of the average American during the past two decades, none is more striking than the change in diet. Ordinarily railway transportation is not thought of as affecting so vital a matter in the life of a people as an essential change in the kind of food they eat. Nevertheless, it is true that improved transportation of perishable products has brought about, or at least contributed greatly to, this change.

It is only in recent years that better refrigeration and expedited movement of fresh fruits and vegetables have brought to every city and village throughout the entire country every day in the year the products from those sections of the United States which specialize in horticultural delicacies. Advantages of a balanced diet containing fresh foods have been brought to the attention of the public by research and medical science, and the ability to grow these special products to greatest perfection has been developed simultaneously with the improvement in transportation which made practicable their distribution over such wide areas. In this way science in health, in horticulture, and in railway transportation, has coordinated to contribute towards happiness and longer life for many millions of people.

Perhaps the most remarkable example of how these changes affected a well-known product is the glorification of the lowly lettuce, which always has been a plant in the household garden. Some few years ago the fact was featured that certain vitamins which it contains are particularly desirable. Along with this came the development of head lettuce, which largely has taken the place of the old-fashioned leaf lettuce. The result has been that the shipment of lettuce over long distances has grown in the United States from 12,000 cars in 1920 to 55,000 cars in 1930.

Head lettuce is grown perhaps to greatest perfection along the Pacific Coast and in some of the western mountain valleys. A few years ago this would have prohibited its general use in the eastern states because of the perishable character of so delicate a plant. What has happened in this instance is typical of many others. Lettuce is not a new plant, but modern science and engineering have contributed to create a great consumptive demand which, in turn, has resulted in an attractiveness of the product as well as a distribution bringing about the growth of a great and extensive enterprise featuring an old-fashioned vegetable.

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**Editor's Note:** Pursuant to the invitation of The Engineering Foundation, the editors will be happy to receive comments, suggestions, criticisms, or discussions pertaining to this or the other articles published in this series.

# Abstracts

## Of Papers Presented at the Winter Convention

INTERPRETIVE abstracts of the majority of papers presented at the A.I.E.E. winter convention (January 25-29, 1932) or articles based upon them, were published in the January issue of ELECTRICAL ENGINEERING. Interpretive abstracts of all remaining papers are presented herewith. Members vitally interested and wishing to obtain immediately pamphlet copies of any available papers are requested to use the order form appearing on p. 148 of this issue. In response to popular demand and within its space limitations ELECTRICAL ENGINEERING subsequently may publish certain of these papers, or technical articles based upon them.

## Aging and Elastic Hysteresis in Instrument Springs

By
R. W. Carson[1]
P. MacGahan[1]

ACCURACY of electrical measuring instruments depends as much on the quality of the control springs as on the design of the torque producing elements. However, judging from the work published on the subject, the design of high quality control springs has not received its proper share of attention.

Unstable effects found in the use of spiral instrument springs arise from a temperature change in the elastic modulus of the spring material, from secular change or aging in service, and from elastic hysteresis, all of which may under certain conditions introduce appreciable errors.

Secular change or aging in service was found to be caused by residual stresses in the spiral spring arising from the manufacturing process and was eliminated by a low temperature heat treatment. Elastic hysteresis was studied with the use of the grid glow micrometer. A study of the effect of composition and cold working, residual stresses and thermal treatment, temperature, intensity, and duration of loading on elastic hysteresis effects lead to an improved manufacturing process.

## An Automatic Oscillograph

By
C. M. Hathaway[6]
R. C. Buell[6]

AS A RESULT of the new era of extensive interconnection of large power systems and of the high speed operation of switches and circuit breakers, problems have arisen that only an oscillograph can solve; further an oscillograph for such applications must have characteristics that are not found in those designed for more general usage.

An oscillograph for such applications of course must be fully automatic because short circuits and faults are usually unanticipated, it should be able to take a considerable number of records successively whether the faults follow each other in rapid succession or are days or weeks apart, and it should start recording within one-half cycle of the beginning of the initiating disturbance. The automatic oscillograph described in this paper has been designed to meet these requirements, being intended primarily for the recording of chance and unanticipated disturbances in power systems and in electrical machinery. (A.I.E.E. Paper No. 32-47)

## Surge-Proof Transformers

By
H. V. Putman[25]

TWO FEATURES in connection with recently improved transformer construction are of special interest: First, without the use of shields to neutralize ground capacity, it has been possible to build shell type transformers in which the distribution of surge voltages is substantially uniform, and which are practically non-oscillating even for the longest surges; second, a major improvement in the impulse strength of the insulation has been made through the elimination of creepage surfaces from the entire insulation structure.

Ordinary methods of shielding, even though equalizing the voltage stress on the insulation between turns and coils, still permit high stress concentrations in the major insulation between windings and ground at the ends of the coil columns or groups. Furthermore, shielded transformers require most careful consideration in design, because of the introduction of large metal surfaces at line potentials in close proximity to the entire high voltage winding. The initial distribution in the new surge-proof transformers not only is substantially uniform within the winding, but the voltage stress is fairly uniformly distributed throughout the entire insulation structure. These results have been obtained simply by employing proper design proportions and coil arrangements, no shields being used. Further improvement in operation has been secured by many years of research on transformer insulation. (A.I.E.E. Paper No. 32-29)

## Effect of Transient Voltages on Power Transformer Design—IV

By
K. K. Palueff[8]
J. H. Hagenguth[8]

THE IMPACT of a surge on the high voltage terminals of a transformer produces transient voltages not only within that winding, but also within the low voltage winding and at its terminals. The latter voltage, discussed in this paper, is impressed on the network and apparatus connected to the secondary winding. The possibility of the transmission of high transient voltages through transformers is indicated by occasional failures during lightning storms of rotating apparatus connected to lines through transformers.

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[1] Westinghouse Elec. & Mfg. Co., Newark, N. J.
[2] Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
[6] General Electric Company, Schenectady, N. Y.
[8] General Electric Company, Pittsfield, Mass.
[17] Bell Telephone Laboratories, Inc., New York, N. Y.

The transient voltage on the secondary circuit may be considered as the result of superposition of four components; namely, electrostatic voltage, free oscillation in the high voltage winding, free oscillation in the low voltage winding, and electromagnetic induction. All four components depend to a different degree upon surge impedances and lengths of external circuits connected to the transformer. A study of these surge voltages enables definite conclusions to be drawn concerning the voltages produced on the secondary circuits, especially those caused by the electromagnetic component, which is of more general importance than the others. **(A.I.E.E. Paper No. 32-49)**

## Standard Decrement Curves

By
W. C. Hahn[22]
C. F. Wagner[2]

THE DETERMINATION of decrement in power system short-circuit currents frequently is necessary for circuit breaker and relay application. For this purpose certain standard decrement curves originally appearing in 1918 and revised in 1923, have been in general use. New decrement curves now have been derived to supersede the former ones, the new curves having been made desirable by the considerable progress in analysis of transients in synchronous machines, and to the use of symmetrical components for calculating unbalanced faults.

The new decrement curves take into consideration the fact that the a-c. component is made up of two exponential terms, and that the transient time constant varies with system reactance. Because the new curves are based upon the method of symmetrical components, a single set is applicable to three-phase, line-to-line, and line-to-ground faults. Distinction is made between machines with and without damper windings.

In addition to presenting these curves the paper includes also the underlying assumptions upon which they are based, the method of their application, and their limitations. **(A.I.E.E. Paper No. 32-53)**

## Calculation of Short Circuits on Power Systems

By
C. F. Wagner[2]
S. H. Wright[23]

CURVES presented in the companion paper "Standard Decrement Curves" are sufficiently accurate for most commercial work, particularly circuit breaker applications. Many special cases arise, however, for which these curves are not applicable. Of this character are relay applications on power systems involving several machines having different time constants and located unsymmetrically with respect to the fault. The individual branch currents in systems of this character may have widely different decrements and even may increase with time. Need, therefore, exists for a method of calculation which will take these individual variations into consideration. Such a method has been developed and has been termed the "internal voltage" method of calculation. It is particularly valuable in that it lends itself to the use of the calculating board and thus minimizes the labor involved.

In the present paper, part I is concerned with an extension of the standard decrement curves and part II with a discussion of the internal voltage method of calculation. Another important factor affecting short-circuit currents is the effect of the increase in exciter voltage during system faults. In part III is developed a semi-graphical method of determining this factor. **(A.I.E.E. Paper No. 32M4)**

## Decrement Curves for Specific Systems

By
W. C. Hahn[22]

GENERAL curves showing the current decay during system short circuits are given in the companion paper "Standard Decrement Curves." Inasmuch as arrangements of systems and characteristics of synchronous machinery vary considerably, a single set of general curves based upon certain assumptions as to system layouts, time constants, etc., will be only approximate, and in some cases considerably in error. It is desirable therefore to have available more accurate methods for obtaining decrement factors. It is the purpose of the present paper to describe the methods by which are obtained these more accurate decrement factors especially adaptable to specific arrangements.

The curves in the companion paper are constructed upon the idea of only one necessary calculation: that required to obtain the initial subtransient current in the short circuit. This may be called a one-point method. It is possible, however, to use the same curves in a more accurate manner by making two calculations based, for example, upon the initial subtransient and transient currents. Use then is made of the general decrement curves having the same ratio of subtransient to transient current as the actual system. A different procedure based on a three-point method may also be used. **(A.I.E.E. Paper No. 32M5)**

## Cobalt Magnet Steel

By
P. H. Brace[2]

IN THE iron-cobalt series, an alloy, $Fe_2Co$, having the highest known saturation intensity of magnetization was discovered. This led to the development of new and remarkable permanent magnet steels based on that alloy. The better of these showed residual induction equal to, and coercive forces three to five times as great as, those of the better magnet steels previously available.

As a result, relatively short and light permanent magnets capable of maintaining high field intensities became possible. Advantage of this has been taken in the construction of portable oscillographs; compasses, ignition magnetos and generators for aircraft; indicating and watt-hour meters; magnetic survey apparatus; telephone receivers and traffic control equipment.

The basic alloy $Fe_2Co$ alone is useless as a permanent magnet material. Its utility in this connection results from addition of less than eight per cent of alloying elements in fairly definite proportion, supplemented by appropriate heat treatment. From the magnetic standpoint the best composition contains the following approximate percentages: iron 54, cobalt 38, chromium 4, tungsten 2, carbon 0.95, manganese 0.5, and minor elements and impurities 0.55.

At the present price of two dollars per pound, such material cannot compete with the usual magnet steels on the basis of material cost per unit of magnetic performance and hence its use is economically justified only when savings of space or weight or its high coercive force can be capitalized. Compromise alloys of lower cost and less magnetic ability have become available.

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[22] General Electric Co., Chicago, Ill.

[23] Buffalo Niagara and Eastern Power Corp., Buffalo, N. Y.

Cobalt represents the chief item of cost, but world resources, notably in Africa, Canada and the United States appear such as to give hope for improvement as a larger and more stable market develops. The reported consumption of high-cobalt magnet steel is now of the order of 75,000 lbs. per year. Six manufacturers of alloy steel in the United States are in a position to supply cobalt magnet steel. **Pamphlet copies not available.**

## High Capacity Rectifier Efficiency Improved by Sectionalizing

By
A. L. Atherton[2]

THE IDEA of the sectional type mercury arc rectifier is based on the obvious, but heretofore apparently unrecognized, fact that the best inherent possibilities are realized only in the smaller sizes. Efficiency, reliability, economy, and flexibility are all far better in small units than in large.

Multiple installations of the conventional small capacity units which have been available in the past are impracticable. The new sectionalized rectifier although built in sections, is installed, controlled, protected, and used as a whole, and the desirable qualities of the small rectifier thus are made available for the larger capacities while the disadvantages of sectionalizing are so reduced as to become negligible. **(A.I.E.E. Paper No. 32-50)**

## Time and Its Measurememt

By
E. W. Brown[24]

A TIMEKEEPER, whether terrestrial or celestial, may be considered as consisting essentially of a fixed dial and a moving pointer. A complete observation may be regarded as a comparison of the angles described by the pointers of two timekeepers between two signals.

The measurement of time is considered in this paper from the standpoint of securing the greatest possible accuracy for use in scientific studies, and far more accurately than needed in everyday life. Standard timekeepers are discussed and definitions of error, rate, and other factors are given.

The fundamental standard for time measurement is the rotation of the earth upon its axis. However, various errors are present in this standard and difficulties are involved in its observation. The difficulties in obtaining an absolutely accurate standard are exemplified in the fact that even the observatories taking the most accurate measurements show differences among themselves. **(A.I.E.E. Paper No. 32-51)**

## Modern Developments in Precision Clocks

By
Alfred L. Loomis[30]
W. A. Marrison[17]

ULTRA-PRECISE practical timekeepers of today can be placed within two classes, depending upon whether the restoring force is gravity, as in pendulum clocks, or elasticity, as in quartz crystal oscillators. The second class is a development of the last decade and was made possible by the vacuum tube and associated electrical circuits. Intercomparisons between timekeepers of the two classes provide a most valuable means for the study of changes in gravity and related phenomena.

The three gravity clocks most often recognized as precisio timekeepers are the Leroy, Riesler, and Shortt; one or more these are to be found in most of the important time laboratorie and astronomical observatories throughout the world. While th crystal clock assembly is more costly than that of a pendulu clock and requires more associated electrical equipment, it is believed that for many purposes it is decidedly superior becaus o its great versatility. **(A.I.E.E. Paper No. 32-52)**

## Direct Printing Over Long Non-Loaded Cables

By
M. H. Woodward[34]
A. F. Connery[34]

NOTWITHSTANDING the rapid progress that has been made in recent years in the application of automatic printers to landline operation, and the continued efforts to apply similar methods to the operation of long non-loaded submarine cables, the siphon recorder, which requires manual translation, still is used almost exclusively in the operation of such circuits. While the recently developed loaded type of submarine cable possesses characteristics which permit of its being operated with a modified form of landline multiplex printing system, the numerous attempts to develop and apply a satisfactory direct printing system to non-loaded cables have not met with complete success.

It is the purpose of this paper to outline briefly the various factors which enter into this problem and to describe a new type of cable printer which has been developed and placed in successful operation on cables between London and New York and also between New York and points in Central and South America and the West Indies. A method is described for the electrical conversion of the non-uniform length combinations of the cable Morse code into a modified five unit code and its application to printers on long non-loaded submarine telegraph cables.

## Vector Theory of Circuits Involving Synchronous Machines

By
I. H. Summers[37]

PREVIOUS publications have shown that calculations of the performance of a synchronous machine may be simplified by the use of two scalar impedance operators which apply separately to the component of armature current which magnetizes in the axis of the poles, and to the component which magnetizes in the axis of the interpolar space.

The present paper describes a method of combining these two scalar operators into a single vector operator which applies directly to the total current. With the new operator it becomes possible to write out the complete equations which apply to various numbers of interconnected machines, under various operating conditions, as readily as would be possible if each machine were replaced by a fixed source of voltage operating through a constant value of impedance. The effect is to simplify the labor greatly and thus to extend the scope of synchronous machine analysis, particularly in cases in which more than one machine is involved. It is believed that the theory developed will be of value to engineers who are working on problems such as stability, hunting, pulling into step, and other problems of this general character which involve detailed analysis of the operation of synchronous apparatus under transient conditions. An introduction to this article has been prepared by R. H. Park. **(A.I.E.E. Paper No. 32-48)**

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[24] Yale University, New Haven, Conn.

[25] Westinghouse Elec. & Mfg. Co., Sharon, Pa.

[30] Loomis Laboratory, Tuxedo Park, N. Y.

[34] International Communications Laboratories, Inc., New York, N. Y.

[37] Deceased. Formerly of the General Elec. Co., Schenectady, N. Y.

# Great Lakes District to Meet at Milwaukee

COOPERATION of local educators, manufacturers' representatives, and public utility men has enabled a technical program covering a variety of interests to be arranged for the three-day meeting of the A.I.E.E. Great Lakes District, No. 5, which will be held at Milwaukee, Wis., March 14-16, 1932. Headquarters will be in The New Pfister Hotel. In addition to the technical program, Milwaukee and its environs with their well known industries should hold much of unusual interest for the visitor.

### TECHNICAL SESSIONS

Three technical sessions will be held, one on each day of the meeting. The first session embraces papers in the fields of electrophysics, research, and communication. The second session will bring forth papers on the development of the Waukegan Station and its electrical design features; another paper will describe a 115,000-kw. turbo-alternator; two others will treat line wire insulation and factors affecting spark-over of insulators and bushings. The third session will be devoted to problems in connection with railway electrification and transmission. A student session also will be held and papers by the students within the District will be presented.

The many interesting inspection trips and entertainment features being arranged will be announced later.

### HOTEL RESERVATIONS

Members should make their reservations by writing directly to the hotel preferred. Rates for the headquarters hotel, The New Pfister, as well as several other hotels are given in the accompanying table.

## Tentative Technical Program

### Monday, March 14

**Session No. 1**—*Presiding:* C. F. Harding

The Proximity Effect and Its Application to the Concentration of Heating Currents, Edward Bennett, University of Wisconsin.

*A General Method of Gaseous Tube Control, Carroll Stansbury, Cutler-Hammer, Inc.

*Electrical Instruments in the Gas Industry, E. X. Schmidt, Cutler-Hammer, Inc.

*Toll Switching Plan for Wisconsin, W. C. Lallier, Wisconsin Telephone Co.

*Police Teletypewriter System, R. E. Pierce, American Tel. and Tel. Co.

### Tuesday, March 15

**Session No. 2**—*Presiding:* R. F. Schuchardt

*Development of the Waukegan Station of the Public Service Company of Northern Illinois, J. L. Hecht, Public Service Company of Northern Illinois.

*Electrical Design Features of Waukegan Station, E. C. Williams, Public Service Company of Northern Illinois.

*115,000-Kw. Turbo-Alternator, R. B. Williamson, Allis-Chalmers Mfg. Co.

*Weatherproof Insulation for Line Wires, C. F. Harding, L. L. Carter and J. W. Olsen, Purdue University.

*Factors Affecting Spark-Over of Insulators and Bushings, W. L. Lloyd, General Electric Co.

### Wednesday, March 16

**Session No. 3**—*Presiding:* J. H. Foote

*A 60-Cycle Primary Transmission System, C. D. Brown and E. W. Hatz, The Milwaukee Elec. Ry. & Lt. Co.

*The Mercury Arc Rectifier Applied to A-C. Railway Electrification, O. K. Marti, Allis-Chalmers Mfg. Co.

*Mercury Arc Rectifier *Versus* Rotary Converter Automatic Railway Substations, O. M. Ward, The Milwaukee Elec. Ry. & Lt. Co.

*An Improved Type of Limiting Gap for Protecting Station Apparatus, A. O. Austin, Ohio Insulator Co.

Variation in Diameter and Spacing of Suspension Insulators, J. J. Torok and C. G. Archibald, Westinghouse Elec. & Mfg. Co.

Advance copies of papers for discussion will be sent to members as soon as available, upon written request to A.I.E.E. headquarters, 33 West 39th Street, New York, N. Y. Please indicate by title and name of author the paper or papers requested. At the meeting usually five minutes is allowed each discussor. When a member signifies desire to discuss papers on other subjects or groups he shall be permitted a five-minute period for each subject or group. Discussions are not reported; typewritten copies should be left with the presiding officer.

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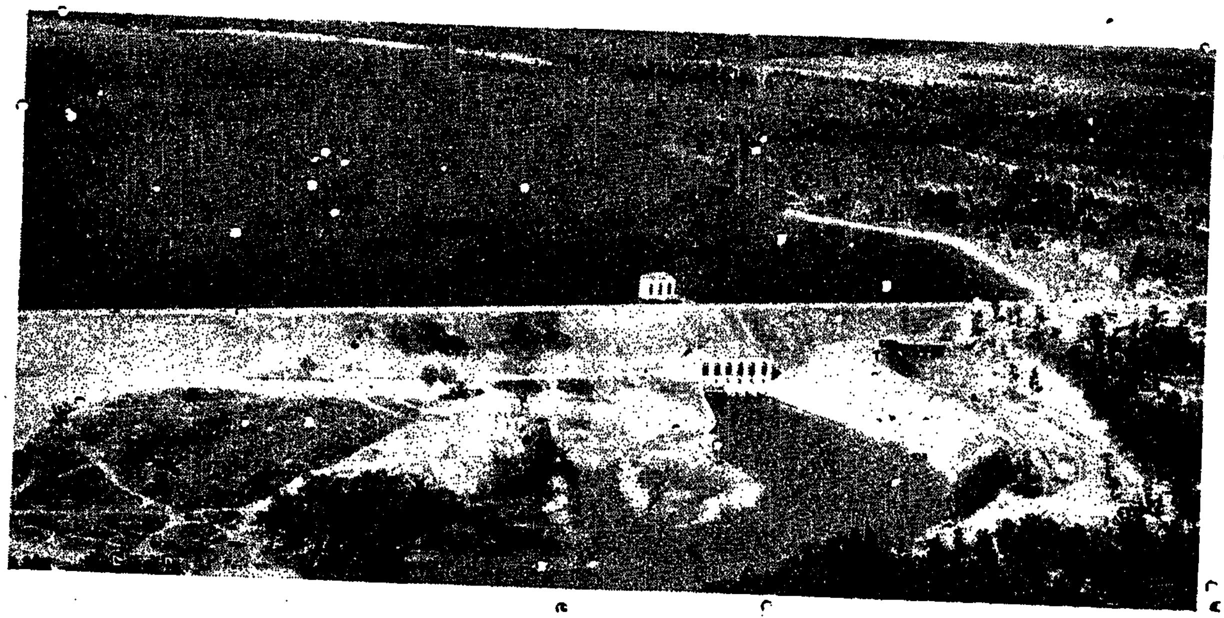
*These papers are under consideration for presentation at the Great Lakes District meeting, but up to the date of going to press have not been officially placed upon the program.

| HOTELS | | ROOMS<br>Without Bath | <br>With Bath | <br>SUITES |
|---|---|---|---|---|
| New Pfister, 200 rooms, Jefferson St. and E. Wisconsin Ave | Single | $2.50 up | $3.50 up | $15.00 |
| | Double | $4.00 up | $5.00 up | up |
| Martin, 200 rooms, 201 East Wisconsin Ave | Single | $1.50–$2.50 | $2.50–$ 3.00 | $ 4.00 |
| | Double | $2.50–$3.25 | $3.50–$ 6.00 | up |
| Medford, 310 rooms, Third and Michigan Sts | Single | $1.75–$2.25 | $2.50–$ 3.00 | |
| | Double | $2.75–$3.00 | $3.50–$ 5.50 | |
| Schroeder, 850 rooms, Fifth St. and Wisconsin Ave | Single | | $3.00–$ 7.00 | $10.00 |
| | Double | | $5.00–$10.00 | up |
| Wisconsin, 460 rooms, 182 Third St | Single | $1.50–$2.00 | $2.50–$ 5.00 | $12.00 to |
| | Double | $3.00–$4.00 | $5.00–$10.00 | $20.00 |

**Date of District No. 2 Meeting.**—Announcement is made by K. A. Hawley, chairman of the Baltimore Section, that the general committee which is arranging the details for the Middle Eastern (No. 2) District meeting in Baltimore, Md., October, 1932, has decided that this convention will be held October 10-14 inclusive. The tentative program arranged includes registration and sessions on October 10 with sessions continued on the following days. A trip to the Safe Harbor hydroelectric plant on the Susquehanna River is planned for October 13.

**Winter Convention Report.**—At the time of going to press for this issue, the 1932 winter convention of the Institute was in progress at the Engineering Societies Building in New York City. A full report of this convention will be given in subsequent issues of ELECTRICAL ENGINEERING.

# Michigan's Largest Dam



HARDY DAM on the Muskegon River supplies the Consumers Power Company over a 48-mile 140-kv. transmission line to Grand Rapids, Michigan. This dam is the largest in Michigan, and among the largest earth dams in the world built on an earth foundation. The dam itself is about 100 ft. high and the pond created has a volume of 160,000 acre ft. The three fully automatic generators are of the vertical type, each rated at 12,500 kva. 60 cycles. Direct-connected main and auxiliary exciters are mounted above the main thrust bearing. The thrust bearings on the generators carry the load of the generator rotors, the waterwheel and the hydraulic thrust of the water passing through the wheel, amounting to a total of approximately 290,000 lb. The generators are enclosed completely and are equipped with water tube air cooling condensers, located below the operating floor which is at exciter level.

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# A.I.E.E. Prizes for Technical Papers

Authors who are presenting papers before the Institute during the calendar year 1932, and others who may wish to submit papers for prizes, would do well to bear in mind that such papers are eligible for consideration for Institute prizes. These awards are made each spring for the preceding calendar year, and fall into two main classes, national and District prizes.

### NATIONAL PRIZES

The national prizes which may be awarded at the discretion of the committee on award of Institute prizes are as follows:

1. Prizes for best papers in (1) *engineering practise*, (2) *theory and research*, and (3) *public relations and education*
2. Prize for initial paper
3. Prize for Branch paper

Each national prize shall consist of a certificate of award issued by the Institute and $100 in cash.

The national prize for best paper in each of the three classes indicated may be awarded to the author or authors of the best original paper presented at any national, District, or Section meeting of the Institute.

The national prize for initial paper may be awarded to the author or authors of the most worthy paper presented at any national, District, or Section meeting of the Institute, provided the author or authors have never previously presented a paper which has been accepted by the technical program committee.

The national prize for Branch paper may be awarded to the author or authors of the best paper based upon undergraduate work presented at a Branch or other Student meeting of the Institute, provided the author or authors are Student Branch members.

All papers submitted for prizes (except for the Branch paper prize) must be written by members of the Institute. When papers are written jointly, the cash awards shall be divided, and a certificate shall be issued to each author.

All papers approved by the technical program committee which are presented at any meeting will be considered by the committee on award for the best paper prizes without being formally offered for competition. All papers other than those presented to the technical program committee must, in order to receive consideration, be submitted in triplicate with a written communication to the national secretary on or before February 15 of the year following the calendar year in which they were presented. This may be done by the author or authors, by an officer of the Institute, or by the executive committees of Sections, or Geographical Districts.

### DISTRICT PRIZES

The following District prizes may be awarded each year in each Geographical District of the Institute.

1. Prize for best paper
2. Prize for initial paper
3. Prize for Branch paper

Each District prize shall consist of a certificate of award issued by the officers of the Geographical District and $25 in cash. It may be awarded only to an author who, or to co-authors of whom at least one, is located within the District, and for a paper presented at a meeting held within, or under the auspices of, the District. When papers are written jointly, the cash awards shall be divided and a certificate shall be issued to each author.

The District prize for best paper may be awarded for the best paper presented at a national, District, or Section meeting.

The District prize for initial paper may be awarded for the best paper presented at a national, District, or Section meeting, provided the author or authors have never before presented a paper before a national, District, or Section meeting of the Institute.

The District prize for Branch paper may be awarded for the best paper based on underground work presented at a Branch or other Student Meeting of the Institute, the author or authors of which are Student Branch members.

All papers to be considered in competition for District prizes must be submitted in duplicate by the authors or by the officers of the Branch, Section, or District concerned to the District committee on awards on or before January 10 of the year following the calendar year in which the papers have been presented.

All papers submitted for prizes (except for the District prize for Branch paper) must be written by members of the Institute. When papers are written jointly at least one of the authors must be a member of the Institute.

Copies of a pamphlet entitled "National and District Prizes" may be secured, without charge, upon application to Institute headquarters.

**Federal Radio Act Passes Senate.**—On January 4, 1932, the U. S. Senate passed Senate bill 1,037 which would amend the federal radio act of 1927 so as to transfer the existing radio division from the Department of Commerce to the Federal Radio Commission. This is a reorganization measure which will consolidate and simplify the federal government's activities in regulation of radio matters.

## Montefiore Award to be Made Soon

Announcement has been made of the conditions of the George Montefiore prize which will be awarded this year by the Institut Electrotechnique Montefiore of Liege, Belgium. The prize consists of the interest on 150,000 Belgian francs at 3 per cent and is given triennially in international competition for the best original work presented on scientific advancement or on progress in the technical application of electricity in any field. Only achievements made public during the three years preceding the award will be considered. Manuscripts may be submitted in English, in printed or typewritten form, and must be in the hands of the jury not later than April 30, 1932.

The awarding of the prize is in the hands of a jury of ten electrical engineers composed of five from Belgium and five from other countries, acting under the president of the Institute Electrotechnique Montefiore, Omer De Bast. The award is administered through the Association des Ingenieurs Electriciens, or national electrical engineering society of Belgium, with headquarters at Rue Saint Gilles, 31, Liege, Belgium.

## Bibliography on Conductor Vibration

The subcommittee on steel transmission towers and conductors of the power transmission and distribution committee has been working on the problem of vibrating and dancing conductors. As a method of assisting research in this problem, a bibliography has been prepared on vibration, using this term in its broader interpretation.

In compiling this bibliography, all literature available both in this country and abroad has been reviewed to give as complete a reference as possible on this subject. There are six general headings under which these articles have been grouped and which also indicate the relation of associated problems. These six classifications are:

1. Vibration in electrical cables exposed to light winds.
2. Jumping or dancing conductors due to partial glaze coatings and varying ice formations.
3. Wind effects on structures.
4. Wire rope research.
5. Sound and noise.
6. Fatigue and allied researches.

This bibliography is now in mimeographed form and contains a total of 176 items. Any investigators working on this subject may obtain a copy from the chairman of the subcommittee, R. N. Conwell, Public Service Electric and Gas Co., 80 Park Place, Newark, N. J.

## Columbia University Offers E.E. Scholarships

Each year the governing bodies of Columbia University have placed at the disposal of the Institute a scholarship in electrical engineering in the school of mines, engineering, and chemistry of Columbia University, for each class. The scholarship pays $350 toward the annual tuition fees which vary from $340 to $360 according to the details of the course selected. Reappointment of a student to the scholarship for the completion of his course is conditional upon the maintenance of good standing in his work.

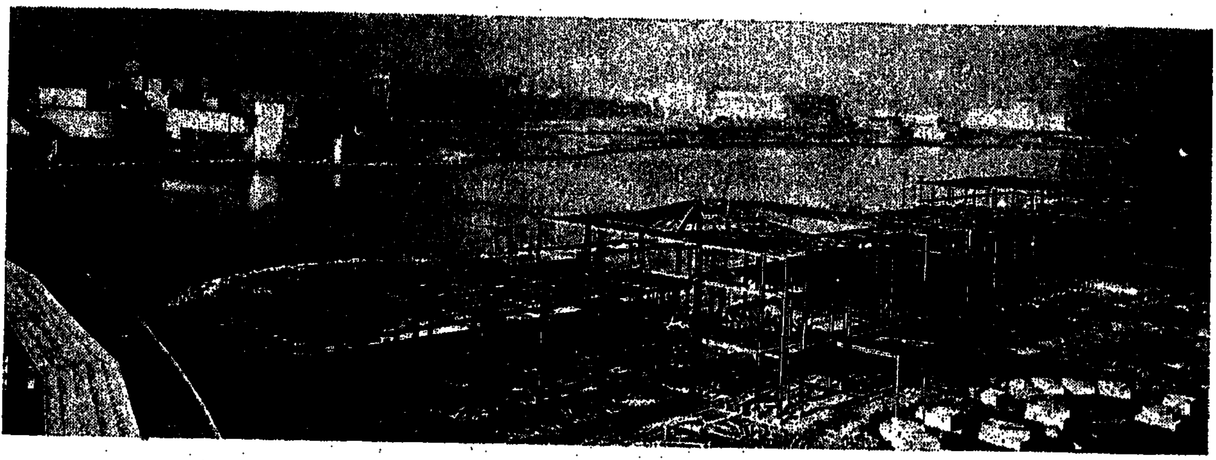
Applicants must meet the regular admission requirements. All letters of application should be addressed to F. L. Hutchinson, National Secretary, A.I.E.E. 33 West 39th St., New York, N. Y., and should give age of candidate, place of birth, education, references, photograph, and reference to any other activities, such as athletics or working one's way through college. The last day for filing applications for the year 1932-33 will be June 1, 1932.

The course at the Columbia School of Mines, Engineering, and Chemistry is a three-year course on a graduate basis. Candidates must have had a general education including considerable work in mathematics, physics, and chemistry. Three years of preparatory work with special attention to the three preparatory subjects mentioned in a good college or scientific school should be sufficient. A college graduate with a B.S. degree in engineering generally can qualify to advantage. The candidate is admitted on the basis of his previous collegiate record without undergoing special examination. Other qualifications being equal, members of Student Branches of the A.I.E.E. will be given preference.

The purpose of this advanced course is to produce a high type of engineer, trained in the humanities as well as in the fundamentals of his profession. It is hoped that Enrolled Students and others qualified will show a keen interest in this scholarship.

**A windowless building,** the first of its kind in the United States, is under construction at Fitchburg, Mass., for the Simonds Saw & Steel Company by the Austin Company of Toledo, Ohio. With solid wall and roof construction and with neither windows nor skylights this new industrial plant is planned to contain 5 acres of floor space and designed to cover practically two city blocks. Francis Keally, New York, is the architect responsible for the design of this $1,500,000 plant, and predicts greatly superior working conditions within the new structure as compared with the more usual design. Elaborate systems to provide high intensity lighting, regulated ventilation absorption of interior noise and elimination of exterior noise are expected to be installed in the building. The lighting system is planned to supply

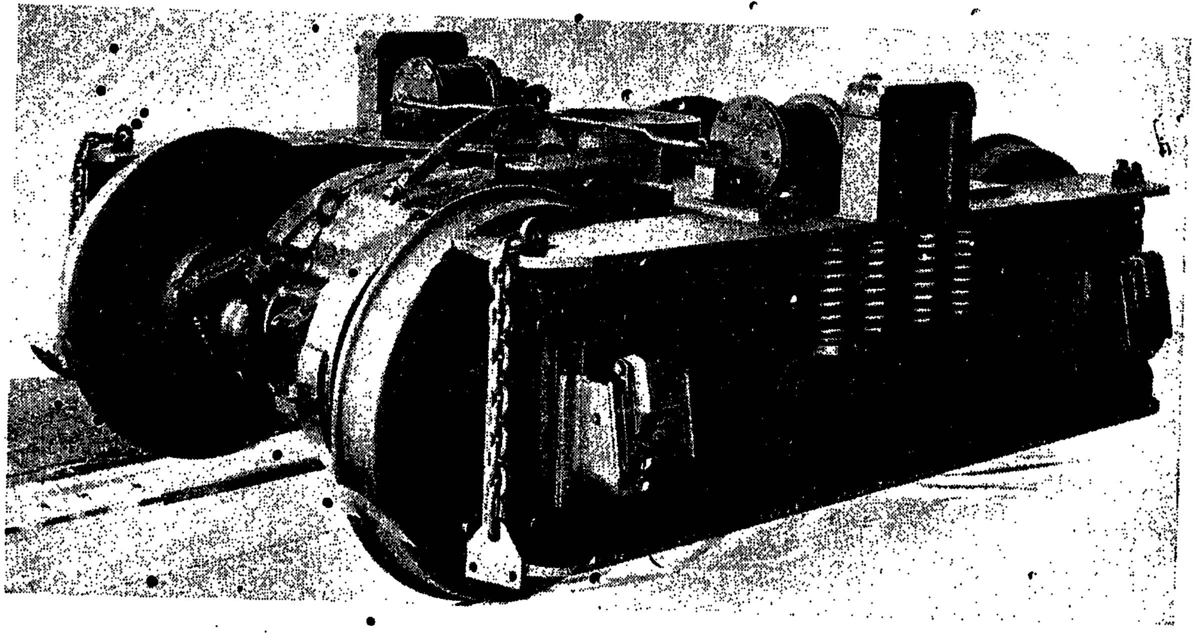
## Construction Progresses for World's Fair



THIS interesting study of part of the electrical group of "A Century of Progress," Chicago's 1933 World's Fair, gives an idea of the rapid progress being made in its construction. When completed, this group will comprise three buildings, a radio building, a communications building and an electrical building. The group will join the mainland site of the exposition by a bridge. In the background of this picture may be seen a view of the 1933 World's Fair site, from the Hall of Science at 16th Street north to the Shedd Aquarium.

a proportion of ultraviolet radiation and a harmonizing color scheme for machinery, and interior decoration is expected to complete the provision of excellent working conditions.—*Michigan Technic.*

## An All-Welded Switching Locomotive



The complete structure of cab, under-frame, and trucks of seven locomotives constructed by the General Electric Company for switching service at Bush Terminal, Brooklyn, N. Y., is fabricated entirely from structural steel shapes and plates, and is arc welded throughout. There are no rivets, and bolts have been used only for those portions requiring occasional removal or renewal. One of the trucks, with motors installed, is shown in the illustration. Each locomotive is of the 60-ton type and has a Diesel-electric power plant, using a 300-hp. engine. The truck frame consists essentially of three members: two side frames of 26-in. 151-lb. girder beams with a 22-in. 108-lb. girder beam serving as the bolster. The bolster beam is welded directly to the side members, the joint surfaces being reinforced with heavy gusset plates and brace plates. All welds on these members are continuous. On the cab, both continuous and intermittent welding are used.

## N.E.L.A. Relay Handbook Reissued With Supplement

The Relay Handbook, originally issued by the National Electric Light Association in 1926, has just appeared in its second edition as "Relay Handbook and Supplement." It was thought best, by the subcommittees of the N.E.L.A. and the protective devices committee of the A.I.E.E. concerned with the revision of the original publication, to bring the book up to date by the addition of supplements to the several sections. All material contained in the supplements is believed to be new and all new relay schemes described have been tested in service unless stated to the contrary.

With regard to "Section I—General Information," it should be kept in mind that while the supplement is devoted entirely to a presentation of the latest symbols used in practise for electric power and wiring, and shortly to be offered for approval as an American Standard, this does not carry with it the inference that the definitions also contained in Section I of the 1926 edition and taken from the 1922 edition of the A.I.E.E. Standards have remained unchanged since that date. Reference to the latest standards of the A.I.E.E. should be made whenever use of the definitions is contemplated. For complete information relative to this handbook apply to N.E.L.A. headquarters, 420 Lexington Avenue, New York, N. Y.

## Lightning Arresters Tested at High Energy

A test has been made which is stated to be the first ever performed on a full size high voltage lightning arrester with surge energy comparable to that met in the field. The newly installed 3,000,000-volt 36,000-watt-second lightning generator at the Sharon Works of the Westinghouse Electric & Manufacturing Company was used in this test.

A 230-kv. station type auto-valve arrester, such as would be used for the protection of 230-kv. transformers, was set up in parallel with the 64-in. relief gap recommended for this voltage class, and a string of fourteen suspension insulators. Surges of various magnitudes and steepness of front were applied from the 3,000,000-volt surge generator. Finally, the full output of the surge generator was discharged through the arrester, the wave front being about three times as steep as the steepest lightning surge yet recorded in the field. The lightning arrester prevented flashover of the 64-in. coordinating relief gap in all cases. In the last test described above, between fifteen and twenty thousand amperes passed through the lightning arrester. However, it is claimed that careful examination showed the arrester to be unharmed.

**Joint Meeting on Metals.**—On Feb. 18, 1932, Sections of the American Society for Testing Materials and the American Institute of Mining and Metallurgical Engineers will hold a joint meeting in the auditorium of the Engineering Societies Building, 33 West 39th Street, New York, N. Y. The general theme of the meeting will be metals; Dr. F. O. Clements will discuss the subject "Limits of our Knowledge of the Properties of Metals," and Prof. H. F. Moore will address the meeting on "Test Results and Service Values of Metals." From long and active connection with the metals field, both of these men are qualified to discuss these subjects ably and with authority. All interested in the subject of metals are cordially invited to attend. The meeting is scheduled to begin at 8 p.m.

**Graduate Courses in Acoustics and Physics.**—Beginning on February 5, 1932, two new graduate courses will be given on Friday evenings at the Polytechnic Institute of Brooklyn, New York. They will be given by Prof. R. B. Lindsay, visiting professor of theoretical physics from Brown University, and are entitled "Acoustics" and "Statistical Theories in Modern Physics."

The course in acoustics will begin with a rapid review of the simpler properties of sound waves and will proceed through the development of fundamental mathematical theory to the more important practical problems. The second course will include an introduction to the use of statistical methods in physics, followed by a presentation of the new statistics of Bose-Einstein and Fermi-Dirac. The latter viewpoints will be applied to the more important electrical and thermal problems. While the treatment will be mathematical, the principal emphasis will be upon the physical significance of the results.

# American Engineering Council

## Annual Meeting and Election of Officers

At the annual meeting of the American Engineering Council in Washington, D. C., January 14-16, 1932, W. S. Lee (A'04, F'13, past-president) of Charlotte, N. C., was elected president for the coming two years. He succeeds C. E. Grunsky of San Francisco, Calif. Gen. R. C. Marshall, Jr., and L. B. Stillwell (A'92, F'12, past-president) both of New York, N. Y., were respectively elected and reelected vice-presidents. Farley Osgood (A'05, F'12, past-president) of New York, N. Y., was named treasurer to succeed Dr. H. E. Howe of Washington, D. C.

The following representatives of the Institute were designated to serve on the administrative board of the Council for the year 1932: C. O. Bickelhaupt, H. A. Kidder, R. F. Schuchardt, C. E. Skinner, and C. E. Stephens.

### Administration of Public Works

Steps also were taken at the annual meeting to aline the engineering profession in support of legislation to create an administration of public works in accordance with the recommendation of President Hoover in his last message to Congress.

The Council will work for the enactment by the present Congress of the bill introduced in the House by Representative Cochran of Missouri "to accelerate public construction in periods of business depression through the creation of an administration of public works and to provide for a more effective coordination and correlation of the public works functions of the government." Numerous amendments to the Cochran measure will be urged upon Congress by the engineers.

The Council has been advocating public works reorganization since it was founded in 1919 under the leadership of Mr. Hoover. Favorable action by Congress now is believed to be probable owing to the disappointment of the people over the failure of public works activity to provide the measure of unemployment relief which had been expected. The taxpayers, it is believed, are aroused to the point where they will demand such a realinement of public works bureaus and services as will respond to national needs in times of economic distress.

Passage of this legislation, it was asserted in the Council's discussion, will be a large factor in bringing about economies in the federal administration and in balancing the federal budget. Presidential sponsorship of public works consolidation will, it was felt, evoke a sympathetic response from both parties in Congress inasmuch as the ends sought are non-political. Many millions of dollars annually will be saved if the public works proposal becomes law, it is held.

The Cochran bill provides for the appointment by the President of an administrator of public works to hold office for fifteen years at an annual salary of $15,000, and for the establishment in the administration of public works of a group of bureaus, each headed by a director, to administer the various public works services.

### Requirements of Administrator

The Council will ask Congress to require that the administrator "shall by training and experience be qualified to administer the affairs of the administration of public works and to evaluate the technical principles and operations involved in the work thereof."

On the motion of L. B. Stillwell (A'92, F'12, past-president) of New York, N. Y., the Council voted opposition to the plan to place the national commission of fine arts under the jurisdiction of the administration of public works. Inclusion of the commission in the administration, Mr. Stillwell said, might deprive the government of the patriotic service of the nation's leading architects.

The engineers will seek an amendment to the Cochran bill placing the design, construction, maintenance, operation and repair of ferries, barges, hospitals, lighthouses, prisons, storehouses, docks, and flood control works under the control of the administrator of public works.

Another engineering amendment would enable the administrator to employ from time to time, outside professional or technical service of competent persons, firms, or corporations, for the architectural and engineering designing, planning and construction of such federal buildings and works as may be placed under his jurisdiction.

Enlargement of the authority of the administrator of public works is asked by the Council in the following amendment:

> "Under the direction of the President, the administrator of public works shall have the power by order or regulation, to consolidate, eliminate, or redistribute the functions of the bureaus, offices, agencies, activities and services in the administration of public works and to create new ones therein and by rules and regulations not inconsistent with law, shall fix the functions thereof and the duties and powers of their respective executive heads."

In adopting the public works program, the Council acted upon the recommendations of the public affairs committee headed by R. F. Schuchardt (A'03, F'13, past-president) of Chicago, Ill.

### Green Bill

The Council sanctioned the measure introduced by Representative Green and sponsored by the American Institute of Architects, authorizing the Secretary of the Treasury to employ private architects in the designing and planning of public buildings. Engineers, however, would make the employment of private architects optional with the Treasury instead of mandatory as provided in the bill. Gen. R. C. Marshall, Jr., of New York, N. Y., head of the construction division of the War Department during the World War, declared that the principle of the bill should apply to all government agencies. The Fulmer bill, which is along the same lines as the Green bill, was opposed. Neither measure would be necessary if the Cochran bill becomes law.

Representatives of the American Institute of Electrical Engineers in attendance were: F. J. Chesterman, W. S. Lee, I. E. Moultrop, Farley Osgood, W. S. Rodman, R. F. Schuchardt, C. F. Scott, C. E. Skinner, and L. B. Stillwell.

## Patents Committee Invites Public Hearings

The patents committee of the House of Representatives is holding public hearings in Washington from January 20, 1932 to March 1, 1932. As indicated in the following four paragraphs taken from a letter under date of January 8, 1932, from W. I. Sirovich, chairman of the committee on patents of the House of Representatives, to L. W. Wallace, executive secretary of the American Engineering Council, the purpose of these hearings is to assist the committee in planning legislation that will meet the approval of the Congress of the United States.

> "Many bills are introduced at each session of Congress for the purpose of amending the patent laws, nevertheless they remain substantially as they were enacted in 1836. As chairman of the committee on patents and copyrights of the House of Representatives of the 72nd Congress, I desire to learn whether the changed economic conditions require amendment, or change, in our patent statutes. To that end I propose to have public hearings before the committee on patents at Washington from January 20, 1932 to March 1, 1932.
>
> "You are cordially invited to attend and give the committee on patents the benefit of your opinion as to what, if any, legislation should be enacted.
>
> "Will you please give this communication as much publicity as possible and invite members of your organization, and any officers or committees interested, to appear before the committee and indicate what, if any, legislation should be enacted.
>
> "As far as possible I wish to meet the convenience of those not residing in Washington, and a definite date for appearance before the committee may be arranged by writing me, indicating how much time is wanted and about when."

**College Course in Radio Offered.**—Through its extension division in Milwaukee, the University of Wisconsin is giving a course in radio communication. This training is of a semi-professional nature with the object of training young men for positions existing in a field between the skilled craftsman and the trained professional engineer. The work is substantially of collegiate grade requiring for entrance a high school education or the equivalent. Completion of the course requires the full time of a student for two semesters, or evening classes over a period of two years. The course may be taken by correspondence also. Satisfactory completion qualifies a student for the government examination for a second-class commercial operator's license.

**Ambrose Swasey** (HM'28) was honored on his eighty-fifth birthday by a luncheon tendered him by officers of the Cleveland (Ohio) chamber of commerce on December 19, 1931. On this occasion about a hundred letters of congratulation were presented to him, and a preview of the Swasey portrait painted by Philip A. de Laszio was made. Among the speakers was Dr. C. W. Rice (A'97-F'12) who paid tribute to Mr. Swasey's many contributions.

# Letters to the Editor

## Discussion of "E.E." Articles Invited

Institute members and subscribers hereby are invited to discuss in these columns any of the articles appearing in ELECTRICAL ENGINEERING. Heretofore discussion has been solicited specifically only on those articles appearing in the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?" Nevertheless, since the introduction of these columns in the September 1931 issue, some readers already have sent in letters on other articles, a few of which were published in subsequent issues.

Because of the many letters received, it is not feasible to publish all, but an endeavor will be made to include those which appear to be of the most general interest. The shorter letters in general are more popular, and hence conciseness is a desirable quality in all cases. ELECTRICAL ENGINEERING reserves the right to publish letters either in full or in part.

## Warning to Welders

*To the Editor:*

I hope you will feel it your duty to issue this warning to welders:

They should not light their cigarettes or cigars from the glowing tip of the electrode when it is still in the electrode handle. This is a very clever or handy trick but some day when their cigarette is damp or their shoes are damp they will get a shock. This can best be described as if a mule kicked them in the jaw and loosened all their teeth. Such a shock might prove fatal if they are working on a scaffold or in a tank or some such place where the release of the tension would throw them off balance. It is always spoken of as "a shock throws one." As a matter of fact, it is the cutting of the rope which you have been straining against trying to release yourself from the muscular tension that "throws you."

Very truly yours,
C. J. HOLSLAG (M'19)
President, Electric Arc Cutting & Welding Co., 152 Jelliff Avenue, Newark, N. J.)

## Nerve Injuries from Electric Shock

*To the Editor:*

I should like to enter protest against the inclusion in ELECTRICAL ENGINEERING of further articles of the type exemplified by "Nerve Injuries from Electric Shock" in the December 1931 issue. I do not believe the average engineer is interested in a subject so remotely connected with engineering.

I suppose the medical journals will still be filled with this class of work, but I do not believe it belongs in quantity in our transactions. It is bad enough to use rats in this work; if we ever use dogs it were better for us if we passed out of existence as a body at that time. I do not believe that kind of engineering is acceptable "On High," and I hope it will not be popular here below.

Pardon if my sincerity has carried me too far.

Yours very truly,
F. G. STRONG (A'91-F'13 and Life Member) 120 Hartford Ave., Wethersfield, Conn.

## Computing the Value of $\sqrt{2}$

*To the Editor:*

Having an occasion to compute the value of the form-factor of sine wave ($\pi/2\sqrt{2}$) to the fifth place of decimals, I felt interested in developing some simple method of computing the value of $\sqrt{2}$, to a high degree of precision. The following two methods evolved in the course of the study might interest some of your readers:

METHOD 1—Expansion into a rapidly conververgent series:

$$2 = \frac{100}{49}(1 - 0.02)$$

therefore

$$\sqrt{2} = \frac{10}{7}(1 - 0.02)^{\frac{1}{2}}$$

By the binomeal theorem

$$\sqrt{2} = \frac{10}{7}\Big[1 - (a + 1/2\, a^2 + 1/2\, a^3 + 5/8\, a^4 + 7/8\, a^5 + \frac{21}{16} a^6 + \frac{33}{16} a^7 + \ldots\ldots \frac{1 \times 3 \times 5 \times 7 \ldots (2n-3)}{(1 \times 2 \times 3 \times \ldots\ldots n)} a^n\Big]$$

where

$a = 0.01$

or

$$\begin{aligned}\sqrt{2} = \frac{10}{7}[1 - {} & 0.01 \\ & 0.00005 \\ & 0.0000005 \\ & 0.00000000625 \\ & 0.0000000000875 \\ & 0.0000000000001312\mathit{5} \\ & 0.0000000000000020625 \quad \text{etc.}]\end{aligned}$$

$$= \frac{10}{7}\left\{1 - (.01005050633883\mathit{3125}\ldots)\right\}$$

$$= \frac{10}{7}\left\{\quad 0.98994949366116\mathit{6875}\ldots\right\}$$

therefore

$$\sqrt{2} = \quad 1.41421356237309\mathit{553}\ldots$$

and

$$\sqrt{\frac{1}{2}} = \frac{1}{2}\sqrt{2} = 0.70710678118654\mathit{7765}$$

For the first seven terms of the series the computation is very simple as illustrated above; beyond this point it begins to be more laborious. Using the first three terms of the series only, the computation can be made almost mentally, giving the result correct to seven places of decimal. Numerals in italics are inaccurate due to omission of terms of higher order.

$$\sqrt{2} = \frac{10}{7}(1 - 0.0100505)$$

$$= \frac{10}{7}(\quad 0.9899495)$$

$$= \quad 1.41421357$$

Even this is much more accurate than the requirement of the original problem.

METHOD 2—Approximating fraction; consider the following series of fractions:

$$\frac{1}{1} \qquad \frac{2}{3} \qquad \frac{5}{7}$$

$$\frac{12}{17} \qquad \frac{29}{41} \qquad \frac{70}{99}$$

$$\frac{169}{239} \qquad \frac{408}{577} \qquad \frac{985}{1393}$$

$$\frac{2378}{3363} \qquad \frac{5741}{8119} \qquad \frac{13860}{19601}$$

$$\frac{33461}{47321} \qquad \frac{80782}{114243} \qquad \frac{195025}{275807}$$

$$\frac{470832}{665857} \qquad \frac{1136689}{1607521} \qquad \frac{2744210}{3880899}$$

$$\frac{6625109}{9369319} \qquad \frac{1599428}{22619537} \qquad \frac{38613965}{54608393}$$

$$\frac{93222358}{131836323} \qquad \frac{225058681}{318281039} \qquad \frac{543339720}{768398401}$$

$$\frac{1311738121}{1855077841} \qquad \frac{3166815962}{4478554083} \qquad \frac{7645370045}{10812186007}$$

$$\frac{18457556052}{26102926097} \qquad \frac{44560482149}{63018038201} \qquad \frac{107578520350}{152139002499}$$

etc. etc. etc.

Each fraction of the above series represents the value of $\sqrt{1/2}$, and when inverted represents the value of $\sqrt{2}$, each subsequent fraction being a closer approximation than the one before. This is most easily verified by squaring any of the above fractions. For example, the squares of the first two rows are:

$$\frac{1}{1} \quad \frac{4}{9} \quad \frac{25}{49} \quad \frac{144}{289} \quad \frac{841}{1641} \quad \frac{4900}{9801}$$

These square fractions are all approximately equal to 1/2, the denominator being in each case equal to twice the numerator, ± 1. This rule applies to all the subsequent fractions.

Each fraction is obtained from the previous fraction by the following procedure:

1. Add the numerator and denominator of any fraction; this gives the numerator of the next fraction.
2. Add this numerator of the new fraction to the numerator of the previous fraction; this gives the denominator of the new fraction.

For example, starting with the fifth fraction (29/41), we get $29 + 41 = 70$, this is the numerator of the next fraction; $29 + 70 = 99$, this is the denominator of this new fraction; this makes the sixth fraction 70/99. For practical use it is not necessary to go beyond the twelfth fraction, which gives the values correct to the eighth place of decimal, *viz.*, $\sqrt{2} = 1.414213564$, and $\sqrt{1/2} = 0.707106782$.

To obtain the fractions of higher order, it is not necessary to go through all the intermediate fractions. If $m/n$ be the fraction of the $m$th order, the fraction of 2 $m$th order is, $2\,m\,n/(4\,m^2 + 1)$, if $m$ is an even figure. For example, the sixth fraction is 70/99; therefore, the twelfth fraction is $2 \times 70 \times 99/(4/70^2) + 1 = 13860/19601$; the twenty-fourth fraction is $2 \times 13860 \times 19601/(4.13860^2 + 1) = 543339720/768398401$; and so on.

The purpose of this letter is not merely to determine accurately the value of $\sqrt{2}$, but to introduce a new and interesting aspect of the theory of numbers. The series has many other interesting properties which need not be discussed in this letter.

Very truly yours,
S. L. GOKHALE (M'20)
General Engineering Lab.,
General Electric Co., Schenectady, N. Y.)

# Engineering Foundation

## Research Procedure Committee Appointed

With the approval and assistance of the Founder Societies, The Engineering Foundation has appointed a research procedure committee composed of one representative from each Founder Society selected from or designated by its main research committee annually, and nominated to the Foundation by its governing board or duly authorized officer, and two members of the Foundation Board.

The members appointed for the year 1932 are Thaddeus Merriman, representing the A.S.C.E., F. M. Becket, representing the A.I.M.E., W. H. Fulweiler, representing the A.S.M.E., L. W. Chubb, (F'21) representing the A.I.E.E., and E. DeGolyer and D. R. Yarnall, members of the Foundation board. The duties of this committee will be to aid the Foundation in ascertaining and meeting the research needs of its Founder societies and in making intelligent selections among the numerous projects in which the four societies are interested individually and collectively.

# Personal

## Honorary Membership Awarded Frank J. Sprague

On December 4, 1931, the board of directors elected Frank J. Sprague (A'87, F'12, past-president) an Honorary Member of the American Institute of Electrical Engineers. This is the highest grade of membership in the Institute and is held by only seven other Americans and three representatives of foreign countries.

Underwood & Underwood

F. J. SPRAGUE

The petition, previously presented to the board, is as follows:

"The undersigned Members and Fellows of the American Institute of Electrical Engineers propose for Honorary Membership, Dr. Frank J. Sprague, as the outstanding pioneer in the development of electric traction. We respectfully request the board to give the name of Dr. Sprague early consideration for this honor."

The following statement was also included with the petition:

"Dr. Sprague was not only the originator of the first successful electric traction, but had the same distinction in regard to the electric elevator. His invention of multiple unit train control was also a work of great importance."

Dr. Sprague has long been outstanding in the profession. He was born at Milford, Conn., July 25, 1857, and in 1878 graduated with honors from the U.S. Naval Academy. On his return in 1880 from a tour around the world as midshipman, he attempted to introduce electric light into the navy. He was ordered to the Crystal Palace Exposition, London, England, in 1882, as a member of the jury and in charge of tests on dynamo-electric machines, gas engines, and electric lights.

Dr. Sprague resigned from the navy in 1883 to take up electrical work, and was an assistant to Mr. Edison in the early development of the electric light. In 1884 he founded the Sprague Electric Railway and Motor Company, and pioneered in the development of electric motors and their application to industrial use. His pioneer work in electric traction followed and under his direction a trolley railway was built at Richmond, Va. in 1887 which well can be called the forerunner of the modern electric railway. Pioneer railway installations also were made in Italy and in Germany. These were followed by many similar systems throughout the world. Dr. Sprague also was active in the introduction of electric high speed and house automatic elevators, founding companies for the carrying on of this activity. In 1895 he invented the multiple-unit system of electric train control which now is so extensively used where two or more locomotive units are under common control. He has been an active advocate of underground rapid transit throughout the whole period of its development in New York City.

He is now president of the Sprague Development Corporation and the Sprague Safety Control and Signal Corporation; and is consulting engineer of the Westinghouse and General Electric companies. As consulting engineer for the Southern Pacific Company he made studies for the electrification of the Sierra-Nevada section of that system.

Dr. Sprague has long been active in Institute affairs, having served on various committees, as well as having been vice-president (1890-92) and president (1892-3). He was selected by both the Institute and the Inventors Guild as a member of the U.S. Naval Consulting Board, and engaged during the World War in the development of fuses, and air and depth bombs. He is also a member and past-president of the New York Electrical Society, the American Institute of Consulting Engineers, and the Inventors Guild; a member of the American Society of Civil Engineers, the New England Society, the New York Historical Society, Ye Old Settlers, the Institution of Electrical Engineers and Institution of Civil Engineers of England; an honorary member of the Franklin Institute and National Electric Light Association; and an associate member of the Society of Naval Architects and Marine Engineers. He was awarded the Gold Medal of the Paris Exposition (1889) for electric railway development; the Elliott Cresson Medal of the Franklin Institute (1904) for the multi-unit system; the Grand Prize for "invention and development in electric railways" at the St. Louis Exposition (1904); the Edison Gold Medal of the Institute "for meritorious achievement in electrical science, engineering and art" (1910); and the Franklin Medal (1921) "for fundamental inventions and achievements in electrical engineering." Dr. Sprague is a member of the University, Century, Bankers, and Railroad clubs.

EVERETT S. LEE (F'30) recently appointed by the General Electric Company, Schenectady, New York, to succeed L. T. Robinson (F'12, deceased) as engineer in charge of the general engineering laboratory, a position of significant responsibility, has served the profession in various representative capacities ever since his graduation from the University of Illinois in 1913. Immediately following graduation, he entered the G.E. test department. Later he went to Union College as an instructor in electrical engineering; his masters degree being awarded him there in 1915. During the war period he returned with a commission of first lieutenant to the University of Illinois as instructor in machine gunnery in its school of aeronautics. Upon his return to civilian duties, he was placed in charge of meters and instruments in the general engineering laboratory of the General Electric Company, later to be made assistant director, the position from which he arrived at his present promotion.

Mr. Lee has served the Institute diligently in the varying capacities of chairman of the A.I.E.E. Schenectady Section (1928-29); Sections committee (1929-32); meetings and papers committee (1927-30); instruments and measurements committee (1927-32, chairman 1927-30); coordination of Institute activities committee (1930-32); and upon the special committee on Institute policies (1931—). He is a member of Tau Beta Pi, Eta Kappa Nu, and Sigma Xi fraternities and also of various honorary engineering and scientific societies.

F. W. CLEMENTS (A'08) formerly state electricity commissioner of Victoria, Australia, has been appointed chairman of the state electricity commission to succeed the late Sir John Monash. Mr. Clements was born in Halstead, Essex, England in 1862, being educated in the public schools in London and also in Germany. His technical education was obtained at the City Guild College, London, supplemented by training at the Great Eastern Railway Works, and the Brush Company, both of London. Between 1881 and 1890 he was with the Brush Company in various capacities, including service as their representative in Hungary, and joint manager of their factory and contract department in Vienna. He later held positions in England, and in 1899 went to Australia being engineer and manager of the Electric Lighting and Traction Company of Australia, later local managing director and chief engineer of the Adelaide Electric Supply Company, South Australia. Mr. Clements later held responsible positions with other Australian companies prior to becoming state electricity commissioner. He is a member of the Institution of Electrical Engineers and the Australian Institute of Engineers.

E. S. LEE

G. C. WARD (M'24), for the last three years executive vice-president of the Southern California Edison Company, Ltd., Los Angeles, Calif., recently was elevated to the rank of senior vice-president of this company. Born in White Plains, N. Y., January 9, 1863, Doctor Ward was educated at Philips Academy, Andover, Mass., and between 1882 and 1902 was location and construction engineer for the following railroads: New York, West Shore and Buffalo; Erie; New York Central; Delaware and Hudson; and Mohawk and Malone. Between 1902 and 1911 he was associated with H. E. Huntington in the Pacific Electric and the Los Angeles railways. Following this he was president of the Pacific Light and Power Corporation, until that company was merged with the Southern California Edison Company in 1917. He then became vice-president in charge of construction and operation of the latter company, and continued in this position until being advanced to executive vice-president three years ago. Under Doctor Ward's generalship the well known engineering developments of his companies have been carried out, starting with the Big Creek plant and continuing through the completion of some 500,000 hp. in steam-electric generating capacity at Long Beach. The University of Southern California has honored him with the degree of doctor of engineering, and Oberlin College has conferred the degree of doctor of science upon him.

SIDNEY HOSMER (F'12) vice-president and L. L. EDGAR (A'12) vice-president, and assistant superintendent, of the Edison Electric Illuminating Company of Boston, Mass., have advanced to the respective offices of vice-president and assistant general manager, and vice-president in charge of the operating bureau; I. E. MOULTROP (F'29 and vice-president) the company's chief engineer, now has been appointed head of its construction bureau. All three of these men are well known as veterans in the utility's employ. Mr. Moultrop has served also as chairman of the Institute's Boston Section, as a member of the Boston Society of Civil Engineers, the National Electric Light Association, the American Standards Association, and vice-president of the American Engineering Council. He long has been a member of the A.S.M.E. power test and boiler code committees, and was on that society's Council three years as manager and two years as vice-president.

M. P. RICE (M'19) manager of publicity, General Electric Company, Schenectady, N. Y., retired as of December 31, 1931, leaving behind him a record of over 37 years of valuable service to the company. It was Mr. Rice himself who in 1903 established the General Electric Review, the company's technical magazine. Under his direction too, the Maqua Company, which produces much of the company's printed matter, was started. In 1921 when the company became interested in radio broadcasting, he was made director of the activity and in this position not only outlined the company's policy in this new field, but also established its three broadcasting stations at Schenectady, N. Y., Oakland, Calif., and Denver, Colo.

C. J. FECHHEIMER (F'14) previously of the power engineering department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has opened his own consulting engineering offices in the Title Guaranty Building, Milwaukee, Wis. Those interested in the development of electrical machinery will recall Mr. Fechheimer as the author of technical literature on this subject. At present he is extending his work in this field by giving a course of lectures on thermal problems in electrical machinery under the auspices of the Milwaukee Extension Division of the University of Wisconsin.

H. W. BIBBER (M'30) on January 1, 1932, left the central station engineering department of the General Electric Company, Schenectady, N. Y., to become associate professor of electrical engineering at Ohio State University. This is not Mr. Bibber's first teaching experience; he was instructor in electrical engineering at Massachusetts Institute of Technology following his return from studies in Ecole Superieure d'Electricite, Paris, and he is a member of the Society for the Promotion of Engineering Education.

W. S. Lee (A'04, F'13, past-president) of Charlotte, N. C., was elected president of the American Engineering Council at its annual meeting in Washington, D. C., January 14-16, 1932. Mr. Lee, who succeeds C. E. Grunsky of San Francisco, Calif., will hold office for two years. At this same meeting L. B. Stillwell (A'92, F'12, past-president) was chosen to continue as vice-president, and Farley Osgood (A'05, F'12, past-president) of New York, N. Y., was named treasurer.

Roy Page (M'21) vice-president and general manager of the Nebraska Power Company, Omaha, Neb., recently was chosen a vice-president of the Citizens' Power and Light Company of Council Bluffs, Iowa. Mr. Page is representative in professional circles in Omaha, having served as president of the Nebraska Section of the National Electric Light Association and also as chairman of the engineering section of the N.E.L.A. Middle West division.

J. M. Gaylord (M'13) formerly chief electrical engineer of the U.S. Bureau of Reclamation, and more recently superintendent of hydro generation for the Southern California Edison Company, Ltd., at Pasadena, Calif., now has been appointed chief electrical engineer of the Metropolitan Water District of Southern California. He has spent forty years on the Pacific Coast and is a widely recognized authority on electrical engineering in its relation to water power.

C. A. Leland, Jr., (M'27) vice-president and general manager of the Des Moines Electric Light Company, the Des Moines Gas Company and the Iowa Power and Light Company has been assigned to the charge of the Kansas utility properties of the North American Light and Power Company. He will retain his supervision of the Iowa holdings, and will operate for the Kansas utilities with his headquarters in Des Moines.

J. J. Smith (A'19) an electrical engineer of the General Electric Company, Schenectady, N. Y., has been appointed to succeed E. S. Lee as one of the assistant engineers of the general engineering laboratory. His association with the company dates from 1916 when he joined its switchboard test department in Schenectady, subsequently going to Pittsfield in the transformer engineering department and returning to Schenectady in 1919.

F. W. Tuck (A'16) formerly with the Pacific Gas and Electric Company as construction foreman and more recently superintendent of electric and line construction for the Anchorage Light and Power Company, now is electrical engineer in charge of construction and operation for Benguet Consolidated Mining Company and chief load despatcher for the North Luzon Power Company, both in the Philippine Islands.

J. M. Donaldson (A'04) chief engineer of the North Metropolitan Electric Power Supply Company, Northmet House, Cannon Hill, England, recently was elected president of the Institution of Electrical Engineers of Great Britain. As the result of earlier engineering work in the United States and Canada, Mr. Donaldson's worth as a professional man is recognized in this country as well as in England.

C. M. Brentlinger (M'27) formerly in the executive offices of the Western Union Telegraph Company, New York, N. Y., on December 1, 1931 was appointed division traffic superintendent for the company's central division comprising the states of Missouri, Kansas, Iowa, Nebraska, Minnesota, and North and South Dakota. His headquarters will be at Omaha, Neb.

E. W. Schilling (A'29) secretary-treasurer of the Iowa Section (1931-2) is now assistant professor of electrical engineering at the Michigan College of Mining and Technology. As instructor at Iowa State College, he completed his work for his degree of master of science, which he was awarded in 1930. He now is working toward his doctorate.

John Bankus (A'20) electrical engineer, Portland Electric Power Company, won the local section prize in the A.I.E.E. Portland Section at the annual meeting held Dec. 8, 1931. His paper portrayed a method of determining economic voltage and cable size for underground transmission.

S. Q. Hayes (F'12) an engineer of the Westinghouse Electric and Manufacturing Company, consulting engineer for the City of Quito, Ecuador, in 1928, and for the Quito Electric Light and Power Company in 1931, recently returned from Ecuador as its vice consul in Pittsburgh, Pa.

W. E. Thau (M'21) who has been director of marine engineering for Westinghouse Electric and Manufacturing Company, New York City, now has gone to the company's office at Lester, Pa. with the new title of manager of the marine general engineering division.

Otto Hartig (A'31) who has been serving as factory engineer for the Eagle Electric Manufacturing Company, Inc., Brooklyn, N. Y., now is occupied with emergency work for the hospital department, New York City, as mechanical draftsman.

A. N. Geyer (A'21) for several years has been associated with the Utah Power and Light Company of Salt Lake City, as maintenance engineer; now he has gone to Seattle, Washington, to identify himself with the Woodward Governor Company.

John Mann (A'31) designer of reactors and accessories and consultant on construction for the Metropolitan Device Corporation, Brooklyn, N. Y., now is electro-acoustical engineer in the Photo-electric Research Laboratory, Inc., New York, N. Y.

Kennard Moss (Student Member) a recent graduate of Texas Agricultural and Mechanical College is now in the employ of the Gulf Refining Company's engineering department, Port Arthur, Texas. His friends may reach him at 100 Lakeshore Drive, that city.

Harold Watkins (A'27) who has been in the electricity department of the Public Works Department, Freetown, Sierra Leone, West Africa, now has been made chief electrical engineer for the government of Sierra Leone, as announced late in December.

W. J. Walker (A'17) who has been serving the General Electric Company at Schenectady, N. Y. in railway supply and renewal parts sales, transportation department, now has been transferred to the company's works at Erie, Pa., in like capacity.

R. W. Sorensen (F'19) professor of electrical engineering at the California Institute of Technology, Pasadena, Calif., has been selected to serve on the board of directors for the Metropolitan Water District of Southern California.

C. V. Bullen (A'23) has left the electrical engineering department of the University of Oklahoma, Norman, Okla. and is now in the department of electrical engineering of the Texas Technological College, Lubbock, Texas.

Sidney Simpson (M'27) chief assistant electrical engineer for the North Western Railway, Lahore, Punjab, India, now is deputy locomotive superintendent (electrical) for the Eastern Bengal Railway, Kanchrapara, Bengal, India.

**G. B. Pulham** (M'27) for the last six years chief erecting engineer for the Metropolitan-Vickers Electrical Company, Ltd., in India, Burma, and Ceylon, leaves Calcutta February 1932 to return to England.

**C. H. Cutter** (A'28) district manager for the Pacific Electric Manufacturing Corporation at Seattle, Wash., has been appointed business manager for "R.P.M." the monthly paper of the Electric Club of Seattle.

**A. F. Grenell** (A'25) who for some time has been associated with the Bell Telephone Laboratories, Inc., New York, N. Y., now has gone to Honolulu on further engineering service for the laboratories.

**M. Yonezawa** (A'25) electrical engineer, Imperial Government Railways, Marunouchi, Tokyo, Japan, has been chosen as a lecturer at the Tokyo Technical University.

**C. W. Warner** (A'26) electrical engineer for the Florida Corporation at its Tallahassee office, recently was transferred to the company's St. Petersburg, Fla. office.

**E. W. Starr** (A'28) has removed from Elsmere, N. Y., to become instructor in electrical engineering at Cooper Union Institute of Technology, New York City.

**M. P. Colony** (A'23) assistant engineer of the Great Western Power Company, Sacramento, Calif., has joined the Pacific Gas and Electric Company, as estimator.

**Kern Dodge** (M'12) consulting engineer, Philadelphia, Pa., has been made director of public safety of Philadelphia.

# Obituary

**Lewis Starr Streng** (A'04-F'26) vice-president in charge of operation for the Louisville Gas and Electric Company, Louisville, Ky., died December 24, 1931, after an illness of several months. He was born in that city in 1876 and was graduated from Massachusetts Institute of Technology in 1898 with a bachelors degree in electrical engineering. That summer he went into the General Electric Company's test department at Schenectady, remaining there until December. Several times his technical work was interrupted by ill health, but in 1899 he entered the employ of the Peoples Light and Power Company, remaining with its successors, the United Electric Company of New Jersey and finally was promoted to inspector and assistant engineer. This latter office he held also with the Public Service Corporation of New Jersey. In 1906 he returned to his native state as chief engineer of the Kentucky Electric Company. For the Louisville Gas and Electric Company he was first chief engineer, then general superintendent before his later elevation to the vice-presidency. Two years ago Mr. Streng was placed in charge of purchases. Besides his membership in the Institute, he also belonged to The American Society of Mechanical Engineers, the American Gas Association, National Electric Light Association, Association of Edison Illuminating Companies, Engineers and Architects Club of Louisville, Electric Club, Standard Country Club and Quindecim Club.

L. S. STRENG

**Raymond Stanislous Masson** (A'99) widely known western consulting electrical engineer and former president of the Needles (Calif.) Gas and Electric Company, died at his home in Los Angeles, Calif., December 17, 1931. As consulting engineer for the Henry E. Huntington properties in southern and central California, Mr. Masson directed the construction of the first 40,000-volt transmission line in California, a line built in connection with the Borel hydroelectric plant of the Pacific Light and Power Corporation, a Huntington property which later became a part of the Southern California Edison system. Mr. Masson was born in Hammondsport, N. Y. in 1870, and did not retire from active business until 1929, when he was forced to do so because of ill health. He was graduated from Lehigh University with the class of 1892. From July 1892 to June 1893 he worked for the Field Engineering Company of New York on the Buffalo Railroad and several suburban roads; also on the construction of machinery and underground systems. The next year he joined the Westinghouse Electric and Manufacturing Company, spending 18 months in the shops at Pittsburgh, Pa., six months as switchboard operator at Niagara Falls Power Company, and two years in the San Francisco office as district engineer and salesman. He was at one time president and general manager of the Culiacan, Sinaloa, Mexico Electric Company.

**William Nesbit** (A'02-F'29) northeastern engineering manager of Westinghouse Electric and Manufacturing Company prior to his retirement two years ago, died December 31, 1931, after a lingering illness. He was born January 20, 1876; in 1895 became assistant electrician of the Central Foundry Company, Lewisburg, Pa. and during 1897-8 he engaged in an apprentice course at the Westinghouse company's main office in East Pittsburgh. The following year he was placed in charge of transformer testing. In 1900 he became transformer designer for the company, and during the interim between that time and 1926 when he took his position as northeastern manager, he was successively sales engineer at the Syracuse office of the Westinghouse company, sales engineer in its New York office, and manager of the company's engineering division in New York. To technical literature he contributed the book "Electrical Characteristics of Transmission Circuits," a work used extensively as a college text-book as well as being generally recognized as of valuable service to transmission engineers. Its compilation covered a period of fifteen years and it was in its fourth edition after the distribution of 12,000 copies in use.

**Bertram Philip Wilber** (A'03) assistant designing engineer, New York Edison Company, Irving Place, New York, N. Y., died at his home in Great Neck, N. Y., the latter part of December 1931. He was born in Philadelphia on the first of March 1871, educated in the public schools of Philadelphia and New York, and in the College of the City of New York, where he took a mechanical course. This he followed by an apprenticeship in the machine shops of the Pennsylvania Railroad Company. When he became interested in electricity much of his elementary study was self-imposed. From 1894 to 1905 was spent in the employ of the New York Edison Company as draftsman, designer, and chief draftsman in the design and construction of power and substations; from 1906 to 1916 he was assistant electrical engineer for L. B. Stillwell, in charge of the drafting office on the design and construction of power plants, factories, estimating, inspection, testing, etc. A year was spent with the Pratt Engineering and Machine Company in the construction of various chemical plants. He also served Westinghouse, Church, Kerr and Company as assistant engineer.

**William Bryan Duncan** (A'20) assistant professor of electrical engineering, Stanford University, Calif., died of pneumonia December 18, 1931. He was thirty-three years of age. Born at Fayetteville, Ark., his general technical education included one year at Stanford University prior to his employment by the San Joaquin Light and Power Company, Bakersfield, Calif. After several years of practical work with this company, he returned to Stanford and earned his bachelor's degree. Using summers and vacations for more work in practical fields, Professor Duncan continued at Stanford University, earning his E.E. degree and at the same time gaining valuable knowledge in actual experience of application. With a change of its teaching force, Stanford University made him instructor in electrical engineering and shortly thereafter advanced him to the assistant professorship. He has been a member of the faculty since 1927. He also had done considerable research in lightning protection for several large oil companies towards protective measures for Pacific Coast tank farms.

# Local Meetings

## Future Section Meetings

**Akron**

Feb. 9—At 4:00 p.m. inspection trip through the Ohio Edison Company's East Akron substation. At 7:45 p.m. movies: "Through Oil Lands." At 8:15 p.m. James H. Foote, Allied Engineers, Inc., will speak on Load Shifting Transformers at Salt Springs. Meeting to be held in the auditorium of the Ohio Edison Co.

March 8—Electrical Refrigeration and Air Conditioning, by W. M. Timmerman, Gen. Elec. Refrigeration Co. Movies. Meeting to be held at Ohio Pwr. Co., Canton, preceded by dinner at Elks Club.

**Baltimore**

Feb. 19—Some Features of Interest in Motor Driven Water Pumping Stations, by Leon Small, water engr., City of Baltimore.

March 18—Subject to be announced. Speaker: Captain Greenlee, Director of Naval Experimental Station.

**Chicago**

Feb. 10—Modern Underground Cable Practise, by Herman Halperin, Commonwealth Edison Co.

March 17—Coordination of Insulation, by F. E. Andrews, Pub. Serv. Co. of Northern Illinois.

**Cleveland**

Feb. 18—Lightning—Recent Investigations and Findings, by K. B. McEachron, Gen. Elec. Co., Schenectady, N. Y.

March 24—Joint meeting with Case School of Applied Science Branch. Speaker: Dr. Dayton C. Miller.

**Dallas**

Feb. 26—Speaker: Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co.

March 21—Underground Construction and Cable Developments, by John Oram, Dallas Pwr. & Lt. Co. Meeting to be held in Fort Worth, Texas.

**Detroit-Ann Arbor**

Feb. 16—Fundamental Physical and Psychological Aspects of Television, by J. O. Perrine, Am. Tel. & Tel. Co. Demonstrations. Meeting to be held in the auditorium of the Michigan Bell Tel. Co.

March 15—Vacuum Tubes and Their Application, by E. H. Vedder, Westinghouse Elec. & Mfg. Co.

**Lehigh Valley**

Feb. 12—Airplane and Ship to Shore Communication, by Lloyd Espenschied, Am. Tel. & Tel. Co. Meeting to be held in Chamber of Commerce Bldg., Scranton.

March 18—Research—Industry's Health Insurance, by S. M. Kintner, Westinghouse Elec. & Mfg. Co.

**Louisville**

Feb. 19—Lightning—Recent Investigations and Findings, by F. W. Peek, Jr., Gen. Elec. Co.

March 18—Men Who Have Made Electrical Engineering History. Meeting under the auspices of students at Univ. of Louisville. Demonstrations.

**Lynn**

Feb. 17—Ladies' night.

Feb. 24—Mercury Vapor Steam Cycle, by Messrs. Sheldon and Coulsen.

March 9—Miracles in Nature, by Doctor Pillsbury.

**New York**

Power Group, Feb. 18—A-C. Low-Voltage Networks, by C. W. Pickells, New York & Queens Elec. Lt. & Pwr. Co.; A. Pinto, Otis Elevator Co.; L. A. Nettleton, Brooklyn Edison Co. Meeting to be held at 7:30 p.m. in the auditorium, Pub. Serv. Elec. and Gas Co., 80 Park Place, Newark, N.J. Nominations for officers of the Power Group for the year 1932-33 will be received at this meeting.

**Pittsburgh**

Feb. 9—New Developments in Mercury Arc Rectifiers. Speaker from Westinghouse Elec. & Mfg. Co.

March 8—Joint meeting with Association of Iron & Steel Elec. Engrs., and Engineers' Society of Western Penn.

**Pittsfield**

Feb. 16—Man-Made Islands to Speed Ocean Flying, by E. R. Armstrong.

March—Competitive meeting with Schenectady Section.

March 1—Famous Women Spies and Their Methods, by Major Coulson.

**Seattle**

Feb.—Communication Meeting. Speaker to be provided by the Am. Tel. & Tel. Co. Joint meeting with Inst. of Radio Engrs.

March—Annual joint meeting of founder societies.

**Spokane**

Feb. 26—Speaker: Dean H. V. Carpenter, State College of Washington and vice-pres. A.I.E.E.

March 25—Joint meeting with the Student Branches of the State College of Washington and University of Idaho. Papers by local members and students.

**Vancouver**

March 7—Students' night.

## Past Section Meetings

**Baltimore**

Television—Its Physical, Fundamental, and Psychological Principles, by J. O. Perrine, Am. Tel. & Tel. Co. Demonstrations. Dinner meeting. Dec. 18. Att. 650.

**Boston**

Vertical Transportation, by A. S. Noyes, Otis Elevator Co. Illustrated. Films—"Virginia" and "Buried Sunshine." Dec. 8. Att. 65.

**Cleveland**

Behind the Scenes, by Zay Jeffries, Gen. Elec. Co. W. L. Enfield outlined developments in lamp construction. Inspection trip through the lamp development laboratory of the Gen. Elec. Co., moving pictures, and dinner. Dec. 17. Att. 173.

**Dallas**

Social meeting. Dec. 10. Att. 86.

**Denver**

Control of Commodity Prices, by M. F. Coolbaugh, Colorado School of Mines. Dinner. Dec. 18. Att. 20.

Precision Instruments, by A. W. Ainsworth, Wm. Ainsworth & Sons. Dinner. Nov. 20. Att. 53.

**Erie**

Electrons at Work and at Play, by Phillips Thomas, Westinghouse Elec. & Mfg. Co. Dec. 15. Att. 250.

**Florida**

Business meeting at which Prof. Melvin Price, chairman Florida State committee on engineers and employment organized by Amer. Engg. Council, spoke on the unemployment situation. Following this session the members took part in the Conference on Student Activities of District No. 4, and gave attention and discussion to many papers presented by students. Prizes were awarded to the authors of the three best papers. The activities were concluded with a banquet at the Hotel Thomas. Dec. 4. Att. 41.

Aims and Activities of the Institute and Electrical Industry in General, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Jan. 4. Att. 50.

**Fort Wayne**

A Method of Symmetrical Components, by C. S. Allen, Gen. Elec. Co.; Heaviside's Operational Calculus, by H. L. Boyer, Gen. Elec. Co. Dec. 17. Att. 32.

**Houston**

Arc Welding in Building Construction, by P. N. Vinther, Dallas Pwr. & Lt. Co. Dinner. Dec. 16. Att. 40.

**Indianapolis-Lafayette**

Some Aspects of the Control of Public Utilities, by Prof. L. M. Sears, Purdue Univ. Joint meeting with N.E.L.A. Dinner. Nov. 5. Att. 150.

Recent Developments in the Electrical Field, by C. W. Fick, Gen. Elec. Co. Illustrated. Dec. 18. Att. 50.

**Iowa**

Present and Future of the Electrical Industry, by H. B. Hoffhaus, Des Moines Elec. Lt. Co.; Transmission for Sale, by C. L. Sampson, Northwestern Bell Tel. Co. Dinner. Dec. 16. Att. 16.

**Kansas City**

Social gathering. Dec. 22. Att. 65.

**Los Angeles**

The Great Australian Bush, by E. T. Bailey, pres. International Adventures. Illustrated. Dinner. Dec. 8. Att. 143.

**Louisville**

The Engineers Place in the Sun, by Prof. W. E. Freeman, Univ. of Kentucky and vice-pres. A.I.E.E. Dec. 18. Att. 65.

**Lynn**

The Story of Lightning, by K. B. McEachron, Gen. Elec. Co. Illustrated. Dec. 16. Att. 350.

Milady Goes Exploring, by Mrs. Elizabeth Dickey. Dec. 2. Att. 1,200.

**Madison**

Joint meeting with the Univ. of Wisconsin Branch at which three papers on Faraday were presented by students. Dec. 10. Att. 53.

**Memphis**

Trackless Trolleys, by A. D. McWhorter, Memphis St. Railway Co. Dec. 8. Att. 35.

**Mexico**

Annual banquet. Nov. 28. Att. 52.

**Montana**

Illumination, by C. S. Bossler, Curtis Lighting Co. Refreshments. Dec. 3. Att. 63.

**New York**

Control of Vehicular Traffic, by R. E. Clisdell, Gen. Elec. Co., S. E. Kelley, Automatic Signal Engg. & Research Corp., and J. G. Hummel, Crouse Hinds Co. Jan. 6. Att. 200.

**Niagara Frontier**

Deion Principle Applied to Large Circuit Breakers and Other Applications, by C. H. Sanford, Westinghouse Elec. & Mfg. Co. Dec. 18. Att. 85.

**Oklahoma City**

Recent Views on Atomic Structure, by Homer L. Dodge, Univ. of Oklahoma. Moving pictures. Dec. 21. Att. 75.

**Philadelphia**

Social gathering. Dec. 14. Att. 250.

**Pittsburgh**

Recent Developments in Electrical Research, by Philips Thomas, Westinghouse Elec. & Mfg. Co. Demonstrations. Joint meeting with Engineers' Soc. of Western Penn. Dec. 8. Att. 160.

**Portland**

The Story of Aluminum, by C. R. Boyle, Aluminum Co. of America. Moving pictures. Nov. 17. Att. 80.

Determination of Economic Voltage and Cable Size for Underground Transmission, by John Bankus, Gen. Elec. Co.; Mechanical Strength of Wire Holders as Determined by Test, by Corbett McLean and M. C. Parker, Northwestern Elec. Co.; Latest Trend in Subway and Trench Lay Cable, by R. C. Schuknecht and T. W. Swartz, Northwestern Elec. Co.; A Special Application of the Potentiometer, by J. L. Watson and R. Gleeson, Gen. Elec. Co. John Bankus awarded $25.00 Section prize for presentation of the best paper. Joint meeting with Oregon State College Branch. Dec. 8. Att. 74.

**Providence**

Deion and Deion Grid Oil Circuit Breakers, by Theodore Braaten, Westinghouse Elec. & Mfg. Co. Dinner. Oct. 13. Att. 40.

Trolley Coaches and Electrically Operated Buses, by J. C. Thirlwall, Gen. Elec. Co. Dinner. Dec. 8. Att. 220.

**St. Louis**

The Osage Hydroelectric Project, by R. R. Wisner, Union Elec. Lt. & Pwr. Co. Film—"Lake of the Ozarks". Dec. 16. Att. 290.

**San Francisco**

California State Water Problem, by Lester S. Ready, consulting engr. Dec. 4. Att. 73.

**Seattle**

Symposium on Rural Electrification, by H. J. Gille, Puget Sound Pwr. & Lt. Co., and L. J. Smith, Secy. State Committee on Relation of Electricity to Agriculture. Dinner. Dec. 15. Att. 66.

**Sharon**

Television—Its Psychological Effects, by J. O. Perrine, Am. Tel. & Tel. Co. Dec. 22. Att. 200.

**Spokane**

Manufacture of Sawdust Briquets, by R. T. Bowling, Potlatch Forests Inc. Dec. 16. Att. 25.

**Syracuse**

Radio—The Giant New Industry, by J. D. Kelly, Westinghouse Elec. & Mfg. Co. Jan. 4. Att. 203.

**Toledo**

Television—Its Fundamental, Physical, and Psychological Principles, by J. O. Perrine, Am. Tel. & Tel. Co. Dec. 10. Att. 800.

**Toronto**

Vibration and Fatigue in Electrical Conductors, by A. E. Davison, J. A. Ingles, and V. M. Martinoff, Hydroelectric Pwr. Comm. of Ontario. Dec. 11. Att. 100.

The Apparent Failure of Democracy, by A. T. DeLury, University College. Joint meeting with Engg. Inst. of Canada. Jan. 8. Att. 250.

**Utah**

Airway Lighting, by Alvin Priel, Dept. of Commerce. Nov. 9. Att. 38.

Elwood Bachman, Gen. Elec. Co., described the electrical installation at the Film Flom Mine of the Hudson Bay Mining and Smelting Co. Dinner. Dec. 14. Att. 32.

**Vancouver**

The Design of the Modern Radio Receiver, by V. W. M. Fouracre, Northern Elec. Co. Dec. 7. Att. 55.

**Washington**

International Comparison of Electrical Standards, by C. W. Vinal, and The International Illuminating Congress of 1931, by E. C. Crittenden, both of Bureau of Standards. Dinner. Dec. 8. Att. 75.

**Worcester**

Adventures in Science, by E. L. Manning, Gen. Elec. Co. Joint meeting with engineering societies in Worcester. Dec. 9. Att. 1,000.

## Past Branch Meetings

**University of Akron**

The Progress of Radio, by John Chenot, student; Refrigeration, by R. Gerber, student. Dec. 9. Att. 15.

**Alabama Polytechnic Institute**

General discussion. Dec. 2. Att. 8.

Machines, by Prof. A. Thomas. T. N. Pyke, student, outlined his experiences at the Conference on Student Activities of District No. 4, held at the Univ. of Florida. Dec. 10. Att. 29.

**University of Arkansas**

Railway Signals, by F. S. Raedels, student; Potentiometers, by M. N. Shofner, student; Use of Library and Technical Journals, by W. J. Pruett, student. Dec. 16. Att. 30.

Standardization Rules, by H. L. Scott, student; Standardization Laboratory, by C. M. Huggler, student; Electrical Standards, by P. H. Johnson, student. Jan. 6. Att. 32.

**Case School of Applied Science**

Lectures and demonstrations on lighting. Dec. 17. Att. 30.

**Catholic University of America**

Transatlantic Cable Laying, by Prof. T. J. McKavanagh, counselor. Illustrated. Dec. 9. Att. 38.

**University of Cincinnati**

Operating Experience with Low Voltage A-C. Networks, by L. L. Bosch, Columbia Engg. & Mgt. Corp. Dec. 9. Att. 40.

**Clemson Agricultural College**

A Mooring Mast on Wheels, by E. C. Parker, student. M. M. Smith, student, outlined current events in the electrical industry. Dec. 10. Att. 33.

Thomas A. Edison, by C. P. Walker, student. Moving pictures. Jan. 7. Att. 30.

**Colorado State Agricultural College**

Organization of Doherty Cadet System of Public Service Co. of Colorado, by Thomas Gray, Public Service Co. of Colo. Dec. 7. Att. 17.

Application of Electrical Heat in Annealing, by John Kay, student. Dec. 14. Att. 18.

**Cooper Union**

The Wilkins Expedition to Polar Regions, by John A. Lundbeck, member of the electrical crew of the submarine "Nautilus." Dec. 11. Att. 65.

**Cornell University**

The Present Economic Situation, by Dean D. S. Kimball. Joint meeting with Ithaca Section. Dec. 11. Att. 52.

**University of Detroit**

Substation Operation, by Francis Moran, student; Radio Receiving Tubes, by Louis McNabb, student. Films—"Audion" and "That Little Big Fellow." Dec. 10. Att. 28.

**University of Florida**

Some Institute Problems, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Jan. 5. Att. 165.

**Georgia School of Technology**

Residence Lighting and Eye Conservation, by H. M. Horton, Gen. Elec. Co. Illustrated. Dec. 8. Att. 55.

**Harvard University**

History and Recent Development of the Kennelly-Heaviside Layer, by H. R. Mimno; Television, by J. H. Wright, student. Dec. 9. Att. 33.

**University of Illinois**

Film—"Blasting the Waterways of America." Dec. 9. Att. 25.

Transformer and Rectifier Connections, by Dean A. S. Langsdorf, Washington Univ. Dec. 17. Att. 160.

**Iowa State College**

Election of officers as follows: E. K. Rohr, chairman; M. D. Buttolph, vice-chairman; A. F. Zissler, secy.; F. G. Holdcroft, treas. Dec. 10. Att. 40.

**University of Kansas**

Klydonograph, by J. D. Swofford, student. Dec. 10. Att. 30.

Election of officers as follows: Wm. Kyte, chairman; Louis Farber, vice-chairman; Max Brauninger, secy.; Glen Wakely, treas. Moving pictures. Jan. 7. Att. 47.

**University of Kentucky**

Short Wave Transmission, by J. C. Starks, student. Dec. 17. Att. 39.

**Lewis Institute**

What Goes on in a Power House, by A. L. Peterson, Commonwealth Edison Co. Dec. 4. Att. 125.

**University of Louisville**

General discussion. Dec. 18. Att. 21.

**Marquette University**

The Electrical Profession, Development, and Organization of the A.I.E.E., by C. H. Krueger, chairman, Milwaukee Sec. Oct. 8. Att. 25.

**Massachusetts Institute of Technology**

Opportunities of the Young Electrical Engineering Graduate in a Large Manufacturing Company, by E. O. Shreve, Gen. Elec. Co. Dinner and smoker followed. Dec. 15. Att. 250.

**University of Michigan**

Commercial Aspects of a Public Utility, by A. D. McLay, Detroit Edison Co. Dec. 8. Att. 62.

**School of Engineering of Milwaukee**

The History of the A.I.E.E., by Taylor Decker and H. R. Spike, students. Film—"The Single Ridge." Dec. 10. Att. 37.

**University of Minnesota**

Inspection trip through the Pillsbury flour mills. Nov. 13. Att. 75.

Life of Faraday, by Edward Loye, student. Dec. 8. Att. 13.

**Mississippi A. & M. College**

The Life of Thomas A. Edison, by C. R. Lillybridge, student. Illustrated. Dec. 8. Att. 30.

**Missouri School of Mines and Metallurgy**

Prof. I. H. Lovett, counselor, and W. O. Woods, chairman, discussed electrification of railways. Rex Horn, student, described the uses of mercury arc rectifiers in electric railways. Dec. 9. Att. 11.

**Montana State College**

Ten papers presented by students. Dec. 3. Att. 119.

Illumination, by E. Bossler, Curtis Lighting Co. Joint meeting with Montana Section. Dec. 3. Att. 34.

Six papers presented by students. Dec. 10. Att. 114.

**University of Nebraska**

The Photoelectric Cell, by P. Jorgeson, student; The Potash Industry of Western Nebraska, by E. Knight, student. Dec. 9. Att. 16.

**University of Nevada**

Brushes and Commutation, by E. Zeigler, Westinghouse Elec. & Mfg. Co. Nov. 18. Att. 22.

**Newark College of Engineering**

Electrical Engineering Experiences in Brazil, by W. V. VanDyck, International Gen. Elec. Co. Dec. 16. Att. 35.

Life of Thomas A. Edison, by Prof. J. C. Peet, counselor. Jan. 4. Att. 14.

**University of New Hampshire**

Motion pictures. Nov. 28. Att. 31.

The Cold Cathode One-Hundred and Ten Volt Gaseous Illumina, by C. C. Dolloff, student. Dec. 5. Att. 30.

**University of New Mexico**

Smoker. Film—"Dynamic America." Dec. 9. Att. 35.

V. Brown, student, described his experiences while employed by the Westinghouse Elec. & Mfg. Co. Dec. 16. Att. 9.

**College of the City of New York**

Informal dance. Nov. 19. Att. 48.

The Life of Faraday and His Contributions to Science, by I. E. Lawlor, student; Faraday and Henry, by J. Raggazzini, student. Dec. 17. Att. 35.

**New York University**

Noise in Machinery, by H. C. Fleming, student; The Use of Photoelectric Cells in Photometry, by E. H. Osterland, student. Nov. 17. Att. 14.

Interurban Railway Transportation, by J. P. Monroe, student; Electron Tubes, by L. E. Dinnar, student. Dec. 1. Att. 15.

**North Carolina State College**

Banquet. Nov. 23. Att. 48.

Home Lighting, by J. C. McKinney, student; Prof. R. S. Fouraker, counselor, and G. E. Ritchie, chairman, gave reports of the activities at the Conference on Student Activities of District No. 4, held at the University of Florida. Dec. 8. Att. 28.

**University of North Dakota**

Relative to Relativity, by Prof. C. W. Byers. Dec. 9. Att. 26.

**Northeastern University**

Cables, Their Construction and Use, by E. W. Davis, Simplex Wire & Cable Co. Refreshments. Dec. 4. Att. 42.

**Ohio University**

Film—"Buried Sunshine." Jan. 6. Att. 36.

**Oklahoma A. & M. College**

Talks by several students. Nov. 23. Att. 25.

The Development, Theory, and Application of Watt-Hour Meters, by Harold Brown, student. Dec. 7. Att. 30.

**Oregon State College**

Joint meeting with the Portland Section. (See report under "Past Section Meetings.") Dec. 8. Att. 82.

**Pennsylvania State College**

Railway Signaling Devices and Their Application, by Mr. Rice; The Sonotone and Its Fundamental Construction, by Mr. Holt. Dec. 9. Att. 46.

**Pratt Institute**

Film—"The Story of an Electric Meter." Dec. 21. Att. 24.

**Rensselaer Polytechnic Institute**

A-C. Networks, by D. K. Blake, Gen. Elec. Co. Dec. 8. Att. 100.

**Rhode Island State College**

Film—"The Electric Ship." Dec. 3. Att. 30.

Action of the "Noden Valve" Rectifier, by M. J. Carr, student; The Common "Tungar" Rectifier, by Joseph Strauss and George Freedman, students. Dec. 10. Att. 18.

Inspection trips through the Industrial Trust Building and the Narragansett Elec. Lt. Co., followed by a lecture on Television, by J. O. Perrine, Am. Tel. & Tel. Co. Dec. 15. Att. 18.

Mercury Arc Rectifiers, by J. F. Schmidt, student. Dec. 17. Att. 10.

**Rice Institute**

Discussion. Jan. 6. Att. 11.

**Rose Polytechnic Institute**

Thomas A. Edison, by Wayne Plimmer, student. Dec. 9. Att. 38.

**University of Santa Clara**

Film—"Thomas A. Edison." Joint meeting with A.S.M.E. Dec. 10. Att. 89.

**University of South Carolina**

Election of officers as follows: A. R. Urquhart, chairman; H. G. Smith, vice-chairman; E. C. Salley, secy.-treas. Dec. 10. Att. 31.

**South Dakota State School of Mines**

General discussion. Dec. 3. Att. 30.

**University of Southern California**

Ship to Shore Communication, by Paul Johnson, Pacific Tel. & Tel. Co. Dec. 2. Att. 26.

Applications of Thyratron Tubes, by Berdett Ives, Gen. Elec. Co. Dec. 9. Att. 23.

**Southern Methodist University**

Life Works of Thomas A. Edison, by A. Fellrath, student. Illustrated. Joint meeting with A.S.M.E. Branch. Oct. 9. Att. 32.

**Stanford University**

Inspection trip through Pacific Gas & Elec. Co. Station A. Oct. 24. Att. 22.

Photo-Telegraphy Equipment, by W. Noel Eldred, student. Dec. 3. Att. 21.

Inspection trip through an exchange of Pacific Tel. & Tel. Co., San Francisco. Dec. 4. Att. 23.

**Stevens Institute of Technology**

Talk by Col. C. O. Gunther on the Reserve Officers Training Corps. Dec. 11. Att. 38.

Inspection trip through the U.S.S. Akron and U.S.S. Los Angeles. Nov. 27. Att. 30.

**University of Tennessee**

The Life of Thomas A. Edison, by C. J. Bryn, student. Illustrated. Nov. 25. Att. 65.

**Texas A. & M. College**

General discussion of Branch activities. Dec. 7. Att. 20.

Business meeting. Jan. 7. Att. 25.

**Texas Technological College**

Talks by Prof. L. S. Grandy and Dean Wm. J. Miller on the activities of the A.I.E.E. Film—"Magic of Communications." Nov. 23. Att. 27.

**University of Texas**

H. P. Woods, student, described a new proposed method of solving constants of the Fourier series by means of electromechanical mechanisms. Oct. 22. Att. 12.

**University of Utah**

Sunlight Lamps, by W. Ottenstein, student; Mercury Arc Lamps, by E. I. Christensen, student. Dec. 3. Att. 27.

You, by H. T. Plumb, Gen. Elec. Co. Dec. 10. Att. 55.

**University of Vermont**

Radio Interference, by Mr. Logan, student. Nov. 23. Att. 18.

Film—"The Single Ridge." Dec. 7. Att. 33.

**Virginia Military Institute**

Electrical Refrigeration, by R. J. Meybin, student; "DeForest—The Man Who Made Radio Broadcasting Possible," by J. Roberts, student; An Automatic Diesel Electric Plant, by H. J. Pence, student; The Radio Telephone, by T. J. Moore, student. Dec. 5. Att. 55.

WABC's New Wireless Antenna, by R. P. Sledge, student; Sound Pictures, by C. E. Schoonover, student; The Niagara Power Development, by S. J. Stone, student; A Power Plant That Flies, by G. B. Hightower, student; The Restoration of the Beauty of Niagara, by S. J. Mergenhagen, student. Dec. 22. Att. 54.

The Communication System of the Waldorf-Astoria, by W. L. Kelly, student; The Effects of Electric Shock, by C. S. Betts, student; Neon Electric Signs, by C. A. Payne, student; The Work of the Army Air Corps, by W. P. DeSaussure, student. Jan. 4. Att. 57.

**Virginia Polytechnic Institute**

Reports of the Conference on Student Activities of District No. 4, held at the Univ. of Florida were given by those who attended that meeting. Dec. 10. Att. 36.

**State College of Washington**

Films—"Industrious Diamonds," "The Telephone," and "Voice Highways." Dec. 4. Att. 37.

**Washington University**

Operation of the St. Louis Municipal Police Radio Broadcasting System, by Louis Siech, student. Dec. 11. Att. 17.

**University of Wyoming**

Film—"The Single Ridge." Nov. 20. Att. 21.

The Development of the Microphone, by F. Wickenkamp, student; Electrical Aids to Blind Flying, by T. R. Hance, student. Dec. 1. Att. 6.

**Yale University**

Acoustics, by S. K. Wolfe. Dec. 8. Att. 44.

# Employment Notes

## Of the Engineering Societies Employment Service

## Men Available

### Construction

E.E., 33, 10 yr. practical experience in elect. construction work on new buildings. Familiar with all branches of elect. contracting including estimating, field engg. and purchasing. Has had complete charge of electrical work in various large building projects in New York City. A-850.

ASSOC. E.E., 34, married, technical education, desires position with utility. Exceptional ability in underground transmission and distribution systems. One yr. central station construction experience. Location, immaterial. Available on short notice. D-278.

### Design and Development

E.E. and M.E. grad., 37. 13 yr. comprehensive experience with nationally known firms in designing, drafting, and engineering of modern power plants and substations. Engg. reports and specifications for diesel-electric plants. Inspection and experimental work. Foreign languages. Work and location immaterial. Available immediately. C-8195.

E.E., M.E. DESIGN ENGR. College trained, wide experience development and design; mech. and elec. apparatus; special machinery; thorough knowledge manufacturing; 5 patents. Desires connection where inventive ability and persevering effort to obtain desired results efficiently and economically are essential. Excellent references. N.Y. metropolitan district preferred. B-8219.

PWR. PLANT ENGR. 15 yr. exp. in drafting, design, and construction; elec. and mech., including complete mill and pwr. plant steam generating equipment. English schooling and technical training. American citizen, single. Also some operating and maintenance experience. B-9747.

E.E., grad. 32, married. 8 yr. exp. elec. and mech. design of small motors and fans. Capable of full responsibility for development of a-c. and d-c. motors, generators, and allied products. Up to the minute on capacitor motor design. Middlewest preferred. C-5353.

M.E. and E.E., FORMER CORNELL INSTRUCTOR in machine design for 4 yr., Allis-Chalmers designers and checker 5 yr., served shop apprenticeship, 32, single. Desires teaching or engg. opportunity. Salary open. D-122.

GRAD. E. E., single, 29, Westinghouse engg. and design school graduate course. Five yr. transformer design experience. Desires position with utility, engg. or mfg. concern. D-209.

### Draftsmen

ELEC. DRAFTSMAN, 44, married, 5 yr. experience switchboard, supervisory control wiring diagrams, plant and substation layout. 2,300-volt and 220-kv. distribution system. Available at once. Location, anywhere. D-209.

E. E. GRAD., 1928, single, 27. Experienced in design drafting, estimating and layout of substations, switchboards, wiring diagrams, lighting, conduit, transmission and distribution lines. Desires connection in elec. field. Location, immaterial. D-89.

### Executives

GRAD. ELEC., HYDRO-ELEC. ENGR., 31, married. 2 yr. exp. marine elec. installation. 7 yr. exp. design, construction of steam and hydro pwr. plants, outdoor and indoor substations, transm. and distr. lines, wiring diag., indus. plants, office blds., estimating, preparation of specifications. Desires position where experience counts. Available short notice. Middle Atlantic States preferred. D-212.

ENGG. EXEC., 33, married. Elec. grad., 10 yr. exp. in mgmt., design and constr. with leading utility company and mfgr. Desires position with utility company, mfgr., or consultant where initiative, aggressiveness, and judiciousness will show in results of work. South or West preferred. Available immediately. C-4734.

EXEC., SALES, PURCHASING or as asst. to engr. Grad. engr., 20 yr. exp. in maintenance, contracting, purchasing, and design and layout of mech. and elec. eqpt. of indust. and pwr. plants. Location, N.Y. metropolitan district. B-5050.

E.E. GRAD. Married. 15 yr. with electrification, distribution, generation, substations, motor applications and controls, lighting, etc. as applied to utilities, coal mining, cement mills, elec. furnaces, automotive industries. Experience covers estimates, design, layouts, constr. and maintenance. Utility, mining, or indus. concern desired. C-5277.

EXEC. ASST. to pres. or v.-pres. of holding company or large operating utility. 24 yr. exp. in all phases of operation, production, transmission, distribution, utilization, engineering, and construction of utilities and industrials; also rates and valuations, elec., gas and water systems. D-208.

E.E. Wide indus. background in exec. capacities: elec. and mech. engg., steel industry; devpt. engg., mining industries; comml. and pwr. sales engg., utility field; technical editor in publishing field; versed in economics and mgmt. and able to cooperate with personnel. Available immediately. Location immaterial. B-4905.

E.E., GRAD. 14 yr. exp. with utilities and engg. firms covering engg., design, and valuation of pwr. plants, substations and transm. lines. Desires position with utility or engg. firm where organizing and exec., as well as engg. ability is required. Available immediately. C-9570.

ENGG. EXECUTIVE, 33, E.E. and M.E. Grad., ten yr. experience in mgmt., design, construction, production, accounting, and sales, with steel mill, mfr., and utility desires position as chief engr., works mgr., or other executive capacity where a calm, judicial disposition coupled with initiative and aggressiveness will show up in results. C-1297.

E.E. Grad., 48, married. Twenty-six yr. experience as designing, report, power and executive engineer with 3 engg. and construction firms, including system planning, design, construction cost estimating and construction supervision of power plants, substations and transmission facilities for utilities and industrials, Studies of operating economics. B-4553.

E.E. Grad. R.P.I., 34, married. Five yr. with large mfr. of elec. control equipment. Five yr. with prominent engg. firm as elec. designer on power plant and industrial work. Familiar with physical layout, elec. equipment, and wiring for central stations and industrial plants. B-6274.

E. E. GRAD., 1910, experience principally in power and light elect. engg., desires position offering similar or elec. ry. experience. Eastern location preferred. B-1923.

## ENGINEERING SOCIETIES EMPLOYMENT SERVICE

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E. E., 30, 8 yr. broad utility experience, desires new association. Executive ability, ambitious and seriously seeking opportunity where progress can be expected in exchange for effort. Background of practical and administrative detail in power distribution plants. Keenly interested in rural electrification, coordinated commercial technical problems. Middlewest preferred, not essential. C-9959.

EXECUTIVE ENGR., 54, widower, gen. mgr., small utility. Asst. mgr., dist. mgr. of larger organization. Over 20 yr. executive experience in operation of small town utilities. Also qualified as valuation and rate engr. Available immediately. Location preferred, U.S.A. or Canada. B-7932-321-C-1-San Francisco.

**Financial**

FINANCIAL ENGR., Cornell (M.E.-E.E.). Twelve yr. regulatory commission; 4 with utility holding mgmt. corp.; 8 months intensive course bond buying department leading insurance company; employed almost 4 yr. thereafter on financial and fact finding investigations by outstanding consulting engg. organization. Desires opportunity New York City. Salary open. C-2953.

**Instruction**

UNIV. OF WASHINGTON GRAD., E.E., 2 yr. with Bell Tel. Lab., 5 yr. teaching elec. and mech. engg., and 2 yr. testing and experimental work with bus and truck manufacturer. Desires position with automobile or truck manufacturer, or teaching automotive engg. Available at once. B-7830.

E.E. Grad., 21, single, B.S., 1931, Worcester Polytechnic Inst. desires connection with industry, or with teaching; also interested in drafting. Location, immaterial. Available upon short notice. D-228.

E. E. GRAD., member Tau Beta Pi, Assoc. A.I.E.E., degrees B.S., will teach mathematics, power plant design, or structural design. B-5551.

**Maintenance and Operation**

E.E., 32, married, 12 yr. experience in the construction, maintenance and operation of power house auxiliaries, high voltage switching equipment. Substations, switchboard erection and wiring, control wiring and relay applications. Location, immaterial. Available at once. D-273.

E.E. Grad. 33 years, wide experience in operation and maintenance of both steam and hydro power plants and system operation. Also well educated in modern business and 5 yr. experience in accounting. Excellent references. Will accept position anywhere in U.S. C-7796.

E.E., 29, married. Westinghouse and Western Electric training. Five yr. maintenance and construction, 2 yr. power plant construction and 2 yr. detailing and layout. Desires position with mfg., engg. utility or ry. concern. Location, immaterial. Available on short notice. D-257.

CONSTRUCTION AND MAINTENANCE SUPT., E.E. Grad., 37, married. Thirteen yr. experience in the utility field, particularly in engg., construction and maintenance of distribution and transmission substations. Desires position wish large utility with responsibility for the construction, operation and maintenance of substations. B-2885.

**Research**

1931 E.E. GRAD., 23, single. Desires position with any mfg., utility, concern, or in any elec. engg. field. Prefers position in design and research, or the application and use of vacuum tubes. Willing to start at the bottom. Location, immaterial. Available immediately. D-221.

M.I.T. GRAD. E.E., 35, married. Six yr. industrial and teaching experience in e.e. Several years private research and development work on own initiative. Good ability, integrity, and personality. Desires position for life work. Location preferred, Middlewest or South. C-2826.

PHYSICIST, 32, married, 12 yr. experience in laboratories, large elec. mfrs., desires development engg. with small company. Experience mostly with vacuum or gas discharge devices, good theoretical knowledge of high frequency currents (Harvard graduate); physical chemistry, particularly thermodynamics, theoretical mechanics, and probability theory. B-8390.

**Sales**

COMMERCIAL MGR., 40, married. Grad. E.E. Fifteen yr. elec. pwr. companies in charge of sale of industrial power and equipment. Handled domestic sales. Trained salesmen. Large results. Previous 8 yr. handled men high tension hydroelectric construction and operation. Will consider any location. D-250-3112-C-2-San Francisco.

E. E., Cornell Unv. 1925, G.E. test course and 4 yr. sales engr. with Gen. Elec. Co. Desires position with industrial concern, consulting engg. firm or utility. Southern location preferred but interested in any locality where there is opportunity. Available on short notice. C-7135.

DISTRICT SALES MGR. OR MFR'S AGENT. Experienced engg. representative, desires connection with high grade company that has line of industrial or utility equipment. East preferred. B-4067.

E.E. GRAD., married, 39, wide sales experience with utility and industrial companies on electrical supplies, merchandise, and equipment. Desires position requiring good personality and ability to meet executives as well as a thorough knowledge of selling and of merchandising. B-1196.

**Testing**

1930 E.E., Drexel Inst., 24, single, 1½ yr. experience in making complete electrical tests on distribution, power and rectifier transformers, and metering equipment. Also G.E. test floor experience. Desires position with utility or industrial concern. Available at once. Location, immaterial. C-9913.

**Junior Engineers**

1931 GRAD. E.E., of 5 yr. co-op. school, 23, single. Experience includes machine shop, telephone central office trouble shooting, and large municipal fire alarm system. Desires position with mfr. or utility. Willing to start at bottom. Middlewest preferred; elsewhere satisfactory. C-9825.

1931 E.E. GRAD., Midwestern college, 24, single. One yr. student engr. on G.E. test. References furnished. Available on 2 wk. notice. C-9497.

GRAD. E.E., 1929, single, 23. Fifteen months as student engr. on G.E. test. Some test, drafting, and switchboard construction experience before graduation. Interested in position with concern doing consulting or construction work or with utility or mfr. Available at once. Location anywhere in U.S. C-8028.

1931 GRAD. E.E., single, 22, American. Desires position in the elect. industry with an opportunity for advancement. Chicago resident, location preferred, Middlewest. Available immediately. C-9909.

1931 E.E. Grad., 24, single. Experience in maintenance and installation of power plant equipment, also knowledge of photoelectric cells and pub. address systems. Available immediately. D-289.

1931 E.E. Grad., 24, American, single, Univ. of Virginia, desires position in elect. industry, preferably radio or one of its affiliated branches. Experience in protective relay systems with utility. Has kept up with radio industry since 1920. Salary secondary. Location, U.S. or foreign. D-290.

JUNIOR ENGR., 26, single. Desires connection with utility, sound picture industry or radio mfg. firm. G.E. test course, utility distribution test experience. Test, design, construction, maintenance and engg. work in radio receiver mfg. plant. Location, immaterial. C-8596.

1931 E.E. GRAD., Midwest univ., 23, single. Three months' experience with large utility, 3 months with elect. contacting and construction company. Desires utility work, especially interested in power plants, transmission, distribution, agricultural development. Location, immaterial. D-282.

GRAD. E.E., 27, married, 5 yr. experience with Gen. Elec. Co., including test course, induction motor design, application engg., and district office sales work. Also experience in automotive electrical work. Available on short notice. C-9236.

E. E. GRAD., 22, single. Experienced in power transformer repairing, overhead and underground systems maintenance for pub. utility. Some experience in electric refrigeration and ice cream manufacturing. Specialized in transmission in college. Will consider any job within reason. Location, anywhere. Available at once. C-9418.

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# Membership

## Recommended for Transfer

The board of examiners, at its meetings on the dates indicated below recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

### To Grade of Fellow (Jan. 20, 1932)

Foote, James H., supervising elec. engr., Commonwealth & Southern Corp., Jackson, Mich.

Kloeffler, Royce G., prof. of elec. engg. and head of dept., Kansas State Col., Manhattan.

### To Grade of Member (Dec. 22, 1931)

Cornelius, Clinton C., supt., overhead systems engg. dept., Kansas City Pwr. & Lt. Co., Kansas City, Mo.

Fitz, Ernest S., mgr., prod. & trans., Virginia Elec. & Pwr. Co., Richmond, Va.

Hall, Raymond A., district plant engr., Pacific Tel. & Tel. Co., San Francisco, Calif.

Hollister, Vernon L., consulting engr., prof. elec. engg., Univ. of Nebraska, Lincoln.

Hotopp, Alfred H., Jr., divn. engr., Wired Radio, Inc., Ampere, N.J.

Kalantar, H. Hamaz, elec. engr., New York, N.Y.

Loud, Francis M., engr., Jackson & Moreland, New York, N.Y.

Maxwell, John F., head of distribution divn. E.E. dept., Edison Elec. Illum. Co., Boston, Mass.

McCarty, Roy A., mgr., pwr. engg. dept., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

Mowdawalla, Framroze N., exec. engr., Hydro Elec. Dept., Chepauk, Madras, India

Newton, Edward T., patent examiner, U.S. Pat. Off., Washington, D.C.

Peek, Joseph W., elec. engr., Cleveland Elec. Illum. Co., Cleveland, O.

Wolff, Samuel S., chf. engr., American Elec. Motor Co., Cedarbury, Wis.

### To Grade of Member (Jan. 20, 1932)

Doremus, Francis H., sales engr., Gen. Elec. Co. Denver, Colo.

Ewart, James B., chief engr., The Teleregister Corp., New York

Graff, Murray G., sales engr., Gen. Elec. Co., Denver, Colo.

Halloran, Delavan, asst. engr., N.Y. & Queens Elec. Lt. & Pwr. Co., Flushing, N.Y.

Harte, Charles R., engr., The Connecticut Co., New Haven, Conn.

Kidd, Walter J., design engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

Knutz, Wm. H., engr. of elec. design, Midland United Co., Chicago, Ill.

Lindberg, Wm. A., engr. of circuit design and service investigation, Commonwealth Edison Co., Chicago, Ill.

Stock, Robert J., elec. engr., dept. of pub. utilities, Cincinnati, Ohio

## Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the secretary before February 29, 1932.

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Adams, R.O., Dayton Pwr. & Lt. Co., Ohio

Alger,R.A.,N.J.Bell Tel.Co.,Newark
Allan,F.S.,Bell Tel.Labs.,N.Y.City
Alliason,A.R.,Col.City of Detroit,Mich.
Anderson,G.S.,Pac. Military Academy, Culver City,Calif.
Andres,R.R.,Bell Tel.Labs.,N.Y.City
Arnold,S.,San Jose State Teachers Col.,Calif.
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Asmann,J.W.,Union Gas & Elec.Co.,Cincinnati, Ohio
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**February 1932**

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## Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

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Chilofsky, Joseph, 958 N. 7th St.,Phila. Pa.
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Thakkur, K.B., Box 654, Whiting, Ind.
Thomas, Earl Mead, Int'l Gen. Elec. Co., Schenectady, N.Y.
Titland, Trygve T.,1019 Stanton Ave.,Elizabeth, N.J.

# Engineering Literature

## New Books

### In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during December are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

HANDBOOK OF INDUSTRIAL ELECTRICITY. By M. Kushlan. N. Y., McGraw-Hill Bk. Co., 1931. 535 p., 7x5 in., lea., $4.——A non-technical reference book for those engaged in electrical construction, maintenance, testing, inspection and contracting. It covers wiring for light, power, telephones, and signals in buildings of all kinds and for outdoor installations. Estimating is discussed.

LES MACHINES A COURANTS CONTINUS. By R. Langlois-Berthelot, with a preface by M. Paul Janet. Paris, Gauthier-Villars et Cie, 1931. 289 p., 10x7 in., paper, 75 Fr.——An elementary treatise on continuous-current machines discussing the principles, characteristics, and uses of dynamos and motors from a modern point of view, well fitted to prepare the reader for the study of a-c. machinery.

PERSONNEL MANAGEMENT. By W. D. Scott, R. C. Clothier and S. B. Mathewson. 2nd ed. N. Y., McGraw-Hill Bk. Co., 1931. 583 p., 9x6 in., cloth, $4.——A comprehensive outline of the principles of personnel management as they are understood and applied today, both to the management of individuals and of groups; summarizes experience of many employers; useful both as a text and for reference.

QUEST FOR POWER. By H. P. Vowles and M. W. Vowles. London, Chapman & Hall, Ltd., 1931. 354 p., 9x6 in., cloth, 15s.——The aim of the authors is to present a systematic, connected survey of modern progress in power engineering, displayed in proper perspective against a historical background and suitable for the general reader. This object has been accomplished with unusual success.

POLYPHASE INDUCTION MOTORS. By L. Lagron, trans. fm. French by R. C. Simpson and M. G. Say. London & Glasgow, Blackie & Son, Ltd., 1931. 218 p., 9x6 in., cloth, 15s.——The theory, design and use of the polyphase induction motor and its simpler variants are clearly and concisely described. The complete design of a 45-hp. low-voltage motor is worked out for both slip-ring and cage rotors. A chapter is devoted to testing, and another to power-factor correction and speed control.

YOUR HEALTH—AND YOUR EARNING POWER. N. Y., N.E.L.A., 1931. 181 p., 9x5 in., cloth, $0.65.——This book, prepared for distribution to employees of industrial concerns, is an instructive, non-technical handbook on the care of the body in health and disease. Diet, living habits, personal hygiene, disease prevention, first aid in illness, home nursing and first aid in accidents are discussed in simple, practical fashion.

ALTERNATING - CURRENT BRIDGE METHODS. By B. Hague. 2 ed., Lond. & N. Y., Isaac Pitman & Sons, 1931. 391 p., 9x6 in., cloth, $4.50.——Provides a fairly complete account of the theory and practical working of these methods, useful to post-graduate workers and those engaged in original research or accurate testing. Field is restricted to frequencies not exceeding those used in telephonic research. New edition, revised. Numerous references to original sources.

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A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

BALANCING OF MACHINERY. By C. N. Fletcher. Lond., Emmott & Co., 1931. 172 p., 9x6 in., cloth, 10s 6d.——Balancing of high-speed machinery is discussed from the point of view of the production engineer. The book summarizes the factors that affect balance, describes the better known apparatus for detecting unbalance, and the methods and calculations involved in correcting. Treatment is entirely practical.

COMMUNICATION. By D. O. Woodbury. N. Y., Dodd, Mead & Co., 1931. 280 p., 8x6 in., cloth, $2.50.——A popular account of the evolution of communication by telegraph, telephone, radio, and mail.

INCREDIBLE CARNEGIE, the Life of Andrew Carnegie (1835-1919). By J. K. Winkler. N. Y., Vanguard Press, 1931. 307 p., 9x6 in., cloth, $3.50.——Carnegie's spectacular rise from poverty to great wealth is told in interesting, journalistic fashion in this biography.

INDUSTRIAL HYGIENE for Engineers and Managers. By C. P. McCord, assisted by F. P. Allen. N. Y. & Lond., Harper & Brothers, 1931. 336 p., 10x6 in., cloth, $5.——A handbook on all phases of the preservation of life in industry, in which the latest methods of disease and accident prevention are discussed from the points of view of the physician and the executive.

INTERNATIONALER STROMAUSTAUSCH. By K. Dohrn. Munster i. Westf., Helios-Verlag, 1931. 69 p., 10x6 in., paper, 3.75 RM.——International electrical power networks being formed in Europe and America give rise to important economic and political questions, which are discussed in this pamphlet. The evolution and present condition of international interconnections in Switzerland, Austria, Scandinavia, Germany and Canada are discussed, and the policies adopted are studied.

RADIO TELEGRAPHY AND TELEPHONY. By R. L. Duncan and C. E. Drew. 2 ed. revised and enlarged, N. Y., J. Wiley & Sons; Lond., Chapman & Hall, Ltd. 1931, 1,046 p., 9x6 in., cloth, $7.50.——A comprehensive work, intended for use as a text-book by students and as a practical handbook by operators. The authors have aimed to cover the entire field, from the principles involved to the present complex application of them, in a simple, non-mathematical way.

WIRELESS. By L. B. Turner. Cambridge (England), University Press; New York, Macmillan Co. 1931, 528 p., 9x6 in., cloth, $8.50.——This book aims to present an account of radio theory and practise within the field of telegraphy and telephony which will be readable by a competent electrical engineer who has not studied high-frequency phenomena. The work will be useful to serious students who have passed the elementary stage.

# Selected Items From Current Literature

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 2,000 technical periodicals are given in the following columns. All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page, or make translations of foreign articles at cost.

### AIRCRAFT

**Electric Equipment.** Applications of Electricity in Aircraft, H.A.Campbell. *Aviation Eng.*, v 5, Nov '31, p 13-17. Table gives maximum length to which circuits may be expected to be run; electrical calculations for twin-engined flying boat; wiring diagrams; generators and regulators; battery performance.

A Power Plant that Flies, R.E.Hudson. *Elec. Jl.*, 28, Nov '31, p 605-9. Electrical system designed to combine 100 per cent dependability with extraordinarily light weight.

### ARMATURES

Checking Winding Data with Slide Rule, W.O.Hurlbut. *Maintenance Eng.*, v 89, Oct '31, p 503-4. Outline of method of checking winding data with slide rule with special marks on upper stationary scale.

### BUSBARS

Generator Lead Tunnel Satisfies Many Demands. *Elec. World*, v 98, Nov 21, '31, p 906-7. At Ariel hydroelectric development of Inland Power and Light Co., 13,800-volt leads, which tie 56, 250-kva. generator directly to step-up transformers with only disconnecting switches circuit, are carried through concrete tunnel under transformer platform; layout is shown in some detail.

### CABLES

Use of Buried Cable for Underground Construction, W.R.Bullard. *Elec. World*, v 98, Dec 12, '31, p 1054-7. Suggests extension of use of buried cable to effect construction economies; operating advantages and disadvantages of buried cable.

**Operation.** Cable Operation—'30. *N.E.L.A.—Comm. Rept.* no. 161, Oct '31, 29 p. Rate of failures on high voltage underground systems continued in '30, downward trend in evidence since '26.

**Research.** Cable Research. *N.E.L.A.—Comm. Rept.* no. 160, Oct '31, 6 p. Research projects conducted under direction of cable research subcommittee since its organization, *i.e.*, effect of temperature on rate of deterioration of impregnated cable paper; study of ionization in paper-insulated high-voltage cables; influence of residual air and moisture in impregnated paper insulation. Bibliography.

**Testing.** Acceptance Inspection and Testing of Cable. *N.E.L.A.—Comm. Rept.* no. 162, Oct '31, 12 p. Marked discrepancy encountered at times between measured resistance of conductor and its area has been found to be entirely due to errors in one or more of various measurements. Bibliography.

### COMMUTATOR BRUSHES

Brush Efficiency, A.A.A.Rodriques. *Maintenance Eng.*, v 89, Oct '31, p 495. Practical discussion of proper methods of obtaining high brush efficiency through proper operation and maintenance.

### CONDUCTERS

**Installation.** Raceway Simplified Installation of Converter Leads, S.Watkins. *Elec. World*, v 98, Nov. '31, p 966. Economy in installing runs of heavy leads between supply transformers and two 300- and 500-kva. new rotary converters was solved in industrial plant.

### CONVERTERS

Revamping Old Converters Improves Operation, R. H. Newton. *Power*, v 74, Dec. 8, '31, p 831. Edison Elec. Illum. Co. of Boston revamping 5 of its 2,250-kw., 60-cycle booster converters: design and constructional features.

### CONVEYORS

On and Off Up and Down Automatically, R.G.Lockett. *Maintenance Eng.*, v 89, Oct '31, p 491-4. Design, construction and operating details of automatic vertical conveyor; electric control features.

**Electric Drive.** Individual Drives Operate Cotton Gin Economically, W.D.Sinclair. *Elec. World*, v 98, Nov 21, '31, p 908-9. Features of drives in 10-unit cotton gin; new gin will turn out cotton on shipping platform at figure of 13 kw-hr. per bale; typical installations; specifications of motor drives.

### ELECTRIC FURNACES

**Annealing.** Strip and Sheet Annealing in Electric Furnace with Atmosphere Control, W.S.Scott. *Iron Age*, v 128, Dec 3, '31, p 1422-5 & 32. Design and operation of furnaces for bright annealing developed by Westinghouse E. & M. Co.; savings between $1.50 and $3.50 a ton. (To be concluded.)

**Carburizing.** Electric Carburizing Saves Labor of Eighteen Men, E.F.Davis. *Elec. World*, v 98, Nov 7, '31, p 827-8. By substituting mechanical furnace where elements of time and temperature are under sensitive control and making such a furnace as automatic as practical, two men with two 90-kw. electric furnaces are producing equivalent output to 20 men by old box furnace practise.

**High Temperatures.** Methods of High Temperature Treatment, P.P.Cioffi. *Franklin Inst.—Jl.*, v 212, Nov '31, p 601-12. Direct heating of wire and tape specimens in gases; inductive heating of toroidal specimens; sketch illustrates glass furnace, steel furnace, and Gaede 4-stage mercury diffusion pump.

### ELECTRONS

Classical Electrodynamics and Conservation of Energy, W.F.G.Swann. *Franklin Inst.—Jl.*, v 212, Nov '31, p 563-76. Theoretical mathematical analysis.

### ENGINEERS

**Engineering.** Engineer's Growing Civic Responsibilities, F.L.Stuart. *A.S.C.E.—Trans.*, v 95, '31, p 1294-1302. Presidential address at annual convention at Tacoma, Wash., July 8, '31.

Engineers' Opportunities, F.L.Stuart. *Civil Eng. (N.Y.)*, v 1, Dec '31, p 1337-9. Present economic depression is result of insufficient production in years following war; longer working hours and increased output will constitute essential step in progress toward prosperity.

Future Will Demand More Economics in Engineering, W.S.Monroe. *Elec. World*, v 98, Nov 21, '31, p 904-6. From practical point of view, economics of engineering become largely matter of recognizing importance that fixed charges on investment bear to ultimate value of enterprise; also economics need more engineering; central-station industry has little idle capital in over-built plants; no fear of necessity for rapid write-off of modern stations.

New Competition and New Horizons in Engineering, F.H.McDonald. *Civil Eng. (N.Y.)*, v 1, Dec '31, p 1361-3. Undeveloped fields and modern demands of profession; recent changes in engineering and business which give new outlooks; social responsibility; problems of using goods.

**Earnings.** '30 Earnings of Mechanical Engineers—III. *Mech. Eng.*, v 53, Dec '31, p 876-82. Clippings from chart book of A.S.M.E. committee; earnings in principal industries; earnings and type of work.

**Employment.** Keeping Engineer Employed, H.M.Friend. *Power*, v 74, Dec 8, '31, p 835-6. What some large corporations are doing to maintain their engineering forces intact; wage cuts have been equitable.

**Liability.** Designer of Failed Coal Pocket Guilty of Manslaughter. *Eng. News-Rec.*, v 107, Dec 3, '31, p 899 & 902; editorial p 871. Collapse of New York coal pocket, which caused death of 3 men and injury of 11 others, resulted in conviction of designer by jury for second degree manslaughter.

### GALVANOMETERS

Portable String Galvanometer for Use at Moderate Frequencies, E.W.Marchant, J.K. Burkitt and A.H.Langley. *Sci. Instruments—Jl.*, v 8, July '31, p 209-14. Frequency of vibration of 150-200 per sec.; to secure critical damping, string is arranged in oil-filled case; to maintain proportionality between deflection and current, string is supported at ends by springs. (To be continued.)

### GENERATORS

Parallel Operation of A-C. Generators—II, E.H.Stivender. *Pwr. Plant Eng.*, v 35, Dec 1, '31, p 1147-8. Consideration of use of current-limiting reactors, as related to parallel operation.

### HEAT TREATMENT

Steel Strip and Sheet Annealing in Electric Furnace with Atmosphere Control. *N.E.L.A.—Comm. Rept.* no. 22, Nov '31, 13 p. Report supplements N.E.L.A. Publication No. 141.

### IRON AND STEEL PLANTS

**Electric Frequency.** Follansbee, W.Va. Plant of Follansbee Brothers Company Changes from 25 Cycles to 60 Cycles, J.S.Murray. *Iron & Steel Engr.*, v 8, Nov '31, p 453-66. Old and new plants analyzed; change-over discussed in detail; total demand averaged 3,800 kva.; plant was 100 per cent in operation at time of change.

**Electric Power.** Steel Mill Electrification Reduces Production Costs. *Elec. World*, v 98, Nov 14, '31, p 878-9. Lowered costs result from increased production, difference between purchased power and steam expenses, reduction of unit electricity rate due to increased utilization as result of electrification; Carpenter Steel Co., Reading, Pa.

### LIGHT AND LIGHTING

This Ultraviolet Situation, M.Luckiesh. *Elec. World*, v 98, Nov 7, '31, p 829-32. Curative values of less importance than preventive ones; summary of evidence argues for artificial sunlight; combination of health radiation and illumination advocated.

Size of Object, Visibility and Vision, C.E. Ferree and G.Rand. *Illum. Eng. Soc.—Trans.*, v 26, Oct '31, p 820-56. Effect of changes in size of object on speed of discrimination is studied for different intensities of illumination and different relations of object to background.

### AIRPORT

U.S. Aerodrome Lighting, K.W.Mackall. *Aircraft Eng.*, v 3, Nov '31, p 285-90. Characteristics of various types of lights in current use.

### INDUSTRIAL

Automatic Control of Industrial Lighting, E.H.Vedder and S.G.Hibben. *Mill and Factory Illust.* v 9, Oct '31, p 36-7. Survey of advantages of automatic control; circuit diagram of typical photo-cell automatic unit shows standard Mazda lamp used for pilot.

**Visual Efficiency.** Light and the Human Machine, M.Luckiesh. *Elec. World*, v 98, Dec 5, '31, p 1001-2. Eyes of subjects were tested at beginning and again at close of day's work; results compared and tabulated.

### LINES

**Losses.** Determining Tie Line Losses, H.Estrada and H.A.Dryar. *Elec. World*, v 98, Oct 24, '31, p 745-50. Tie line losses may have considerable effect on economical load allocation and decisions for interchange of energy; method of applying increment losses to these problems; other applications of increment loss are enumerated.

**Rural.** Characteristics of Rural Electric Lines, C.P.Wagner. *Agric. Eng.*, v 12, Nov '31, p 413-15. Presents detailed statistical analysis of territory under discussion.

### LOUD SPEAKERS

Use of Rochelle Salt Crystals for Electrical Reproducers and Microphones, C.B.Sawyer. *Inst. Radio Engrs.—Proc.*, v 19, Nov '31, p 2020-9. Methods developed permit cheap commercial production of Rochelle salt crystals; microphones, pick-ups, and especially speakers are described.

### MOTORS

**Protection.** Thermal Cutouts for Protecting A-C. Motors, H.D.Braley. *Power*, v 74, Nov 17, '31, p 703-5. Thermal cutouts for overload protection compared with protective devices that provide short-circuit protection; characteristics of devices for properly protecting motors against overloads, and types of thermal cutouts.

**Windings.** Winding Calculation Reduced to Single Slide-Rule Setting, W.O.Hurlbut. *Elec. West*, v 67, Nov 1, '31, p 228-9. Method of securing motor winding layout permits easy, rapid calculation of turn per phase and wire size for any given frame size.

### NETWORKS

**Design.** System Plan Alternatives Visualized for Executives, M.M.Samuels. *Elec. World*, v 98, Oct 31, '31, p 778-82. Expansion forecasting affected by current uncertainties; load prognostication on population basis safer than on customer total; significance of each plan can be condensed to tabular form for executive action; sample form used by author for analyzing plan.

**Fluctuation.** Starting Currents on Networks, L.O.Bell. *Elec. Jl.*, v 28, Nov '31, p 615-7. Duquesne Light Co. has tested low tension network to determine how much current can be drawn without causing noticeable flicker in lights.

**Losses.** System Losses—Their Analysis and Reduction, M.M.Koch. *Elec. World*, v 98, Nov 28, '31, p 948-51. Procedure to be followed in analyzing losses; methods of reducing them; samples of balance sheets and form used for detailed analysis of losses.

### OSCILLOGRAPHS

Cathode-Ray Oscillograph Timing Axis, F.T. Brewer. *Electronics*, v 3, Dec '31, p 222-3. Principles of performance of sweeping circuit; circuit diagrams and characteristics.

### PHOTOELECTRIC CELLS

A New Selenium Tube, G.F.Metcalf and A.J. King. *Electronics*, v 3, Dec '31, p 234-5. Characteristics of new FJ-31 cell manufactured by Gen. Elec. Co.; data on typical circuits. Bibliography.

**Applications.** Electronic Control of Machinery, R.F.Yates. *Iron Age*, v 128, Nov 19, '31, p 1299-1300 & 1349. Production gages, in which movement of anvils is amplified electrically by vacuum tube; grid-glow tube used in new stroboscope.

### PHOTOMETERS

Automatic Recording Photoelectric Cell Distribution Photometer, W.F.Little and H.J. Eckweiler. *Illum. Eng. Soc.—Trans.*, v 26, Oct '31, p 810-19. Efforts made to develop recording photometer which accurately integrates flicker from rotating luminaire and which completes, in time short enough to be practicable, continuous-curve record giving complete average candlepower data in surface of sphere.

## POLES, WOODEN

Making of Holding Tests of Guy Anchors. *Telephony*, v 101, Nov 21, '31, p 33-4. Method of making field tests of various types of anchors; photographs show set-up for experiments and also types of failure encountered.

## POTENTIOMETERS

Simple Method for Measurements of Residual Inductance on Potentiometers and Four-Terminal Resistance Coils, N.F.Astbury. *Sci. Instruments—Jl.*, v 8, July '31, p 221-3. Simple bridge method is described for measurement of inductances of potentiometers and four-terminal resistances.

## POWER PLANTS

**Diesel-Electric.** Diesel Stand-By Power in Hydro-Electric Plant, E.Swan. *Power*, v 74, Nov 17, '31, p 708-9. Design and operating characteristics of Central Power Company's Diesel Plant at Kearney, Nebraska; list of equipment.

**Hydroelectric.** Ice As Affecting Power Plants. *A.S.C.E.—Trans.*, v 95, '31, p 1134-5. Final report of committee of power division; surface formations; bottom formations. Bibliography.

Ice Prevention at Racks of Hydraulic Plants. *Pwr. Plant Eng.*, v 35, Nov 15, '31, p 1109-10. Description of two installations of electrically heated racks, also of open-channel and other mechanical methods.

Beauharnois Harnesses St. Lawrence for 2,000,000 Hp. *Elec. World*, v 98, Nov 14, '31, p 860-5. Provision also made for deep waterway; electrically driven machinery used for excavation; detailed illustration of operating gallery between wheel and generator levels.

Safe Harbor Development Adopts Kaplan Turbines. *Elec. World*, v 98, Dec 5, '31, p 992-6. Features of Holtwood plant of Pennsylvania Water & Power Co., and Conowingo plant of Susquehanna Power Co.

**Steam-Electric.** Operating Features of Station A, (San Francisco) C.E.Steinbeck. *Power*, v 74, Nov 17, '31, p 697-702. Summary providing background for detailed operating procedure; diagrams of piping.

## POWER SUPPLY

**Current Theft.** Current Theft and Its Prevention, S.A.Fletcher. *Elec. World*, v 98, Nov 21, '31, p 924-6. Notes on extent of practise; various methods of connecting meter boxes providing means of prevention.

**Rural.** Declares Rural Lines Cost Too Much, J.H.Matthews. *Elec. World*, v 98, Nov 28, '31, p 952-3. Author finds no reason for present farm line costs or quality; contends adequate low cost construction should be standardized.

## RADIO

**Amplifiers.** Audio-frequency compensation methods, J.G.Aceves. *Electronics*, v 3, Dec '31, p 224-5. Methods of compensation of losses in radio-frequency end of radio receivers in audio system; notes on reinforcement of high audio-frequencies and frequency band suppression; use of circuit as scratch filter for phonograph reproduction.

**Antennas.** Radiation Resistance of Complex Antennas, K.Tani. *Nat. Research Council Japan—Reports*, v 1, Aug '31, p 185-97. Theoretical mathematical analysis. (In English.)

**Detectors.** Grid Circuit Linear Detection, J.R.Nelson. *Radio Eng.*, v 11, Nov '31, p 32-4. If same results as are obtained with present detectors could be obtained by less radio-frequency voltage, cheaper radio-frequency amplifier could be used.

**Engineering.** Second Meeting of the International Technical Consulting Committee on Radio Communication, Copenhagen, '31. *Inst. Radio Engrs.—Proc.*, v 19, Dec '31, p 2219-49. 21 opinions which were unanimously approved at the '31 C.C.I.R. meeting are given together with 14 questions for consideration at third meeting to be held in Lisbon, Portugal; list of members of U.S. delegation.

**Frequency.** Notes on Generation of Absolute Frequencies, T.Kujirai and S.Fujitaka. *Nat. Research Council Japan—Reports*, v 1, Aug '31, p 199-201. Authors tried to eliminate intermediate standard tuning fork; generated required frequencies directly from oscillation of pendulum made of single steel rod, with period of about 1.093 sec., kept swinging with constant amplitude. (In English.)

**Interference.** Methods for Measuring Interfering Noises, L.Espenschied. *Inst. Radio Engrs.—Proc.*, v 19, Nov '31, p 1951-4. Various methods of measuring interference which have been found useful in Bell System.

**Measuring Instruments.** A direct Reading Modulation Meter, A.H.Cooper and G.P.Smith. *Wireless Engr. and Experimental Wireless*, v 8, Dec '31, p 647. Instrument does not require calibration from oscillograph or other apparatus; wiring diagram is given.

**Modulators.** Amplitude, Phase, and Frequency Modulation, H.Roder. *Inst. Radio Engrs.—Proc.*, v 19, Dec '31, p 2145-76. Comparative theoretical study of amplitude, phase, and frequency modulation. Bibliography.

**Oscillators.** Constant Frequency Oscillators, F.B.Llewellyn. *Inst. Radio Engrs.—Proc.*, v 19, Dec '31, p 2063-94. Manner in which frequency of vacuum tube oscillators depends upon operating voltages; theory of dependence derived; experimental data showing degree of frequency stability which may be expected as result of application of methods outlined in theory.

A New Treatment of Electron Tube Oscillators With Feed-Back Coupling, C.K.Jen. *Inst. Radio Engrs.—Proc.*, v 19, Dec '31, p 2109-44. Theoretical mathematical analysis.

A Recent Development in Vacuum Tube Oscillator Circuits, J.B.Dow. *Inst. Radio Engrs.—Proc.*, v 19, Dec '31, p 2095-2108. Constant frequency oscillator of two-anode type (UX-865) is described.

Adjustment of Multivibrator for Frequency Division, V.J.Andrew. *Inst. Radio Engrs.—Proc.*, v 19, Nov '31, p 1911-17. In multivibrator controlled by voltage of another frequency bearing harmonic relationship to multivibrator frequency, effect of varying control voltage is analyzed; method for determining best value of this voltage.

Neon Tube Audio-Frequency Oscillator, D. Pollack. *Radio Eng.*, v 11, Nov '31, p 24-5. Surface details and characteristics of oscillators which may be used in any position where sinusoidal waveform is not essential.

Vacuum Tubes as High-Frequency Oscillators, E.D.McArthur and E.E.Spitzer. *Inst. Radio Engrs.—Proc.*, v 19, Nov '31, p 1971-82. Problem of tubes for generating power at wavelengths below five meters is discussed; essential data are given for examples of each type of tube. Bibliography.

**Research.** Recording Characteristics of Radio Signals and Static, S.R.Winters. *Radio Engr.*, v 11, Nov '31, p 36-8. Three-in-one instrument, developed by radio laboratory of Bureau of Standards, measures strength of broadcasting stations, denotes fading of radio signals, and records static; 100-acre laboratory for radio transmission research is established near Fairfax, Va.; description of equipment and circuit diagrams.

**Telephone.** Radio Telephony by Ultra Short Waves, S.Uda. *Nat. Research Council Japan—Reports*, v 1, Aug '31, p 203-5. In previous experiments with decimeter waves, transmitter and receiver were different in construction, so that, for two-way communication, separate transmitter and receiver were needed; equipment much improved and single set now used both for transmitter and receiver.

**Transmission.** Some Observations of Behavior of Earth Currents and Their Correlation with Magnetic Disturbances and Radio Transmission, I.S.Bemis. *Inst. Radio Engrs.—Proc.*, v 19, Nov '31, p 1931-47. Radio transmission data collected on telephone circuits operating between New York and London and between New York and Buenos Aires; earth current data collected on two Bell System lines extending 100 mi. north and west from New York.

New Methods of Frequency Control Employing Long Lines, J.W.Conklin, J.L.Finch and C.W.Hansell. *Inst. Radio Engrs.—Proc.*, v 19, Nov '31, p 1918-30. Practical difficulties encountered in commercial operation of short-wave transmitters summarized; methods for meeting these objections through frequency control by long radio-frequency transmission lines.

**Transmitters.** Frequency Stabilization of Radio Transmitters, Y.Kusunose and S. Ishikawa. *Nat. Research Council Japan—Reports*, v 1, Aug '31, p 157-83. Experimental research with regard to frequency stabilization by means of constant-frequency oscillator; quartz-stabilized oscillator; mechanically-stabilized oscillator; valve-stabilized oscillator. (In English.)

**Waves.** Polarization of High-Frequency Waves and Their Direction Finding, S.Namba, E.Iso and S.Ueno. *Inst. Radio Engrs.—Proc.*, v 19, Nov '31, p 2000-19. Results of experiments which were conducted during past two years for purpose of studying high-frequency transmission phenomena, and some physical explanations deduced therefrom.

## RAILROADS

**A.E.R.A. Reports.** Electrical Section Reports. *A.R.E.A.—Bul.*, v 33, Aug '31, 84 p. Synopsis of reports of electrical section.

**Lackawanna Electrification.** A series of articles dealing with "major features," "new features," "power supply and distribution," "mercury arc rectifiers," "catenary system," "signals and interlocking system," "substations," "testing," etc., occupying practically the entire issue of the Gen. Elec. Rev., v 34, Nov '31, p 597 ff.

**Train Control.** Electronic Equipment in Train Control. *Electronics*, v 3, Dec '31, p 218-20. Reliability of vacuum tubes in industrial applications is shown by their practical use in railway signal control systems.

## RELAYS

**Photoelectric.** Light-Sensitive Relays Now on the Market. *Electronics*, v 3, Nov '31, p 194-5. Discussion covers Westinghouse, General Electric, Allen-Bradley, and Burgess equipment now available commercially.

**Protective.** Automatic Live Line Selection, C.W.Jones. *Elec. World*, v 98, Nov 14, '31, p 876. Scheme developed to select live line under conditions where substation is tapped off two transmission lines through motor-operated air-break switches; wiring diagram.

## SUBSTATIONS

Outdoor Substation Design. *N.E.L.A.—Comm. Rept.* no. 164, Nov '31, 43 p. Notes covering details of substation structures, materials, equipment, and protection.

## TELEPHONE

**Industry.** Present Day Economics of Telephony, R.A.Lumpkin. *Telephony*, v 101, Nov 28, '31, p 14-16. Effects of "depression proof" industry idea in public mind; possibilities and problems of future as shown by results of efforts in past year; newly understood policies outlined.

**Measurements.** Attenuation Measurements on Telephone and Telegraph Lines, J.W.Horton. *Radio Eng.*, v 11, Nov '31, p 25-6. Apparatus and connections for measuring line attenuation by modification of standard method.

**Relays.** Characteristics of Strowger Relays, K.W.Graybill. *Telephone Engr.*, v 35, Nov '31, p 30-1 & 49. Characteristics of various special types of relays; graphs showing details of their operation.

## TELEVISION

New Television System, R.W.Tanner. *Radio Eng.*, v 11, Nov '31, p 27-8. System described has possibilities in throwing received picture directly upon screen, without employing lens; new type of mercury arc tube is used for illumination.

## VACUUM TUBES

New Electron Tubes—Facts and Rumors. *Electronics*, v 3, Dec '31, p 216-7. Editorial announcing new short-wave tube for television, *i.e.*, Triple-Twin tube of Cable Laboratories, combining detector and power stage in same envelope; r.f. pentodes with preliminary rating and characteristics.

**Cathode Ray.** Improvements in Cathode-Ray Tube Design, V.K.Zworykin. *Electronics*, v 3, Nov '31, p 188-90. Tube developed is of hot-cathode, high-vacuum type; focusing done electrostatically; special features afford many new applications of oscillograph, including use as television receiver.

**Cold.** A "Cold" Filamentless Radio Tube, C.W.Hough. *Electronics*, v 3, Nov '41, p 182-3. Tube developed by A.Hund of Ampere, N.J., operates as amplifier, modulator, detector, oscillator; note on cold tube invented in Germany, by G.Seibt.

**Pentode.** Pentode Tubes Used as Triodes, J.R.Nelson. *Electronics*, v. 3, Dec '31, p 226-7 & 254. Curves show pentode characteristics of 247-type, output current and harmonic content of power pentode, effect of by-passing self-bias resistance of push-pull pentodes, and power output and distortion of pentodes in parallel; features of tube used as triode.

**Screen-Grid.** Choosing a Screen-Grid Tube, R.DeCola. *Radio Eng.*, v 11, Dec '31, p 15-16, & 32. Experimental inquiry with reference to characteristics of '235, '551 and '224-type radio tubes.

**Transmitting.** Design and Development of High-Power Oscillator or Amplifier Tube UV-862, R.W.Larsen. *Radio Eng.*, v 11, Dec '31, p 18-22 & 30. Technical account of development of UV-862 transmitter electron tube; table of characteristics and construction details of tube.

**Voltmeters.** Vacuum Tube Theory and Practice. *Telephone Engr.*, v 35, Nov '31, p 23-4 & 36. New type of instrument known as rectifier-type voltmeter; used to measure voltage of any frequency from one to 30,000 cycles with fair accuracy; theory and use of rectifier type voltmeter in telephone plant testing work.

## WELDING

Control of Spot and Flash Welds, G.A. Hughes. *Welding Engr.*, v 16, July '31, p 33-6. Summary of tests on resistance butt welded joints; Lehigh University welding symposiums; comparative Brinell and Rockwell hardness tests made on resistance welds in low carbon steel.

**Houses, Steel-Frame.** Residences of Welded Steel Construction. *Eng. News-Rec.*, v 107, Nov 26, '31, p 839-40. Symposium consisting of 2 papers; comparative cost estimate of steel and wood-frame construction.

**Coal Mines.** Electric Arc Welding in Mines, C.Lee. *Elec. World*, v 98, Nov 28, '31, p 953-4. Economy of welding in coal-mine practise with various types of equipment; curves showing cost of resistance welding *vs.* motor-generator set.

**X-Ray Analysis.** Guaranteed by X-Ray Inspection, W.H.Shipman. *Am. Mach.*, v 75, Nov 5, '31, p 708-9. X-ray inspecting and testing methods at Barberton plant of Babcock and Wilcox Co; cost of continuous use will not be more than $5 per hr. ordinarily.

# Industrial Notes

**Construction Volume in 1931.**—In reviewing construction activities in the final quarter of 1931, as well as in the year itself, the F. W. Dodge Corporation finds that the 1931 total for all types of construction in the thirty-seven states east of the Rockies amounted to $3,092,849,500 in actual contracts awarded in that area. The year's final quarter produced a contract total of $530,141,700 for all classes of construction in these thirty-seven states. Of this total for the last three months of the year, 34 per cent represents construction of public works and utilities, which amounted to $180,178,200. This compares with 32 per cent of the whole in the final quarter of 1930.

**New Southern Agent For Corning Glass.**—The Corning Glass Works, Corning, N. Y., has announced the appointment of the W. L. Rose Equipment Company, in St. Louis, Mo., as agents for the sale of PYREX power insulators in the southern part of Illinois and eastern part of Missouri, and Arkansas, and the western part of Tennessee.

**New Speed Recorder.**—An operation and speed recorder has been developed by the Amthor Testing Instrument Company, Inc., 309 Johnson Street, Brooklyn, N. Y., which automatically produces a detailed record of the speeds and operation of any rotating machine during the entire day. It shows all starting and stopping periods, the revolutions per minute, fluctuations, etc., recorded directly from the action of the machine itself. A few of the more common applications are on turbines for recording operating speeds and the correctness of the over-speed or safety trip, and on engines and motors.

**New Pole-Top Switches.**—The Delta-Star Electric Company, Chicago, announces a new line of two and three-pole, gang operated pole-top switches for distribution line voltages up to 34.5 kv. The tilting insulator carries a hinged loop and as the switch opens this loop travels along, keeping the stranded conductor from dropping down, eliminating the usual hinged links. The insulator pins, levers and fittings are of malleable iron, the channel base of steel. All parts, bolts and nuts at line potential are of non-ferrous metal. Solderless clamp connector terminals are provided for connection to the line conductors.

**New Contact Alloys.**—Pitting of electrical contacts is said to be practically eliminated with the new contact alloys developed by P. R. Mallory & Company, Indianapolis, Indiana. These alloys possess marked advantages over ordinary contact materials. The specific applications are as follows: Alloy known as 3W3 is recommended for oil circuit breakers as well as interrupter contacts for resistance seam welders operating in air. Another, known as 20S, is suitable for arcing tips of very high current density. Still another, G11, is used for arcing tips of low current density and also for make and break contacts where current density is high and non-welding necessary. G13 is used for make and break contacts where current density is high and welding of contacts is not encountered.

**Allen-Bradley Exhibition of Motor Control.**—The most extensive exhibit of motor control equipment ever brought together in Chicago by a single manufacturer will take place during the four weeks beginning February 1st, when the Allen-Bradley Company, of Milwaukee, will display units representing their entire line of motor controllers and accessories. The fifth floor of the Engineering Building, at 205 West Wacker Drive, has been reserved for this display, which will consist of several hundred pieces of Allen-Bradley control equipment, ranging from their smallest photoelectric relay and push-button stations to their largest high-tension automatic starters. The complete line covers controllers for practically all industries and includes standard duty, water-tight, dust-tight, and explosion-proof equipment. The control circuits of the control devices on display will be connected to power feeders so the visitor can observe the operation of the equipment. The exhibit will be in charge of Eugene F. LeNoir, assisted by several members of the Allen-Bradley engineering staff, who, during the four weeks of the exhibit, will give frequent talks before groups of engineers and students.

# Trade Literature

**Transformers.**—Bulletin 148, 24 pp. Describes transformers for instrument and metering service. Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

**Splice Boxes.**—Bulletin, 8 pp. Describes a new and comprehensive line of splice boxes which have been developed because of the increased popularity and possibilities of this type of cable joint. G & W Electric Specialty Company, 7780 Dante Avenue, Chicago, Ill.

**Gearmotors.**—Bulletin 20536, 4 pp. Describes Westinghouse "gearmotors," consisting of speed reducers combined with induction motors into single, self-contained units. Twenty reduction ratios of 1.12:1 to 10:1 are available for each motor speed and horsepower. Westinghouse Electric & Mfg. Co., East Pittsburgh, Penna.

**Motors.**—Bulletin H-1, 14 pp. Describes Star ball-bearing motors designed specifically for hoist duty, with and without built-in brakes. Star Electric Motor Company, Newark, N. J.

**Illumination.**—Bulletin 375-J, 52 pp. Comprises the Holophane "Datalog." This issue contains new developments on lighting equipment for 1932 and includes an engineering section and recommended standards of foot-candles illumination. Holophane Company, Inc., 342 Madison Avenue, New York.

**Ground Tester.**—Bulletin 1300, describes a new small, light weight, direct-reading instrument for measuring ground resistance. This instrument is mounted in a cast aluminum case and weighs 7½ pounds. James G. Biddle Company, 1211 Arch Street, Philadelphia, Penna.

**Floodlighting.**—Bulletin GEA-1505, 4 pp., Floodlighting for outdoor construction; Bulletin GEA-1506, 4 pp., Floodlighting monuments and memorials; Bulletin GEA-1507, 4 pp., Floodlighting for homes and estates; Bulletin GEA-1509, 4 pp., Illumination of parks. General Electric Company, Schenectady, N. Y.

**Mechanical Stokers.**—Catalog, 40 pp. A condensed catalog of mechanical stokers manufactured by fourteen different producers of such equipment. Included are brief but complete descriptions of the most prominent types of stokers. The descriptive matter is confined strictly to engineering data, permitting ready comparison of the various types. Stoker Manufacturers Association, Foot of Walker Street, Detroit, Mich.

**Transformers.**—Bulletin 3110. Describes a new constant current street lighting transformer. This transformer has a unique arrangement whereby both primary and secondary coils move through a small angle thus giving better regulation and a higher power factor. The new unit is represented as having many superior operating characteristics; quiet in operation, low in maintenance cost and has higher operating efficiencies. It is manufactured in all standard sizes from 3 to 30 kva. for both pole and subway use. Moloney Electric Company, 5390 Kingshighway-Bircher St., St. Louis, Mo.

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## This Month—

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Officers and Committees (For complete listing see p. 71-76, January 1932 issue of ELECTRICAL ENGINEERING.)

**F.** L. HUTCHINSON, for the past twenty years national secretary and executive manager of the A.I.E.E., died suddenly, February 26. This sad event occurred during the closing of forms for this issue of Electrical Engineering, but we believe that the readers will pardon the resulting delay. *p. 202-203*

**W**OUND-ROTOR induction machines may be given special characteristics by connecting their rotors and stators in parallel. *p. 171-173*

**W**IDE flexibility in distance measuring characteristics is claimed for a new high speed relay developed especially for short power lines. *p. 157-160*

**G**ENERATOR overvoltage may increase rapidly following sudden loss of load, especially in hydro units; a method for calculating this rise, with a typical example, is given in this issue (*p. 163-167*). Tests show that such overvoltages can be limited to safe values by the use of suitable equipment. *p. 160-163*

**M**ANY A.I.E.E. leaders have received recent recognition in the form of promotions and special awards. *p. 209-214*

**H**AS modern civilization lived up to its lofty mission? Dr. M. I. Pupin, 1932 John Fritz Medalist, raises this question and gives his answer to it. *p. 156-157*

**T**APE armored telephone toll cable buried directly in the ground possesses several advantages over other types of line; special equipment has been developed for laying this cable. *p. 168-171*

**E**NGINEERS through local relief committees, have taken special measures to combat unemployment. Reports of surveys conducted by local A.I.E.E. sections indicate that conditions vary widely. *p. 205-207*

**P**OPULATION forecasts when carefully and intelligently made fill a real need in the planning of engineering projects. Such forecasts are especially valuable to the telephone industry in planning future plant expansion. *p. 185-188*

**L**AST CALL for the A.I.E.E. Great Lakes District meeting to be held March 14-16 at Milwaukee; a few minor changes have been made in the program (*p. 202*). All of the technical papers to be presented are abstracted in this issue. *p. 188-192*

**I**NTERCONNECTION of power systems, to be most advantageous, should be carried out only after a most careful study of the problems of each of the systems involved. Interconnection services are classified and evaluated, and the development and operation of interconnected systems discussed from various angles, in a group of four articles. *p. 174-185*

**A**.I.E.E. winter convention attracted 1,429 registrants, but this was only one of the many factors attesting its success. A report covering the many features of the convention including President Skinner's opening address, two medal presentations, fourteen committee meetings, and the board of directors meeting, may be found in this month's news section. Discussion at technical sessions will be treated in a later issue. *p. 193-202*

# The Engineer and His Responsibilities as a Citizen

**In his opening speech before the Institute at its 1932 winter convention in New York, N. Y., President Skinner stressed the contributions of the engineer to the material development of the country and toward maintaining a high standard of living. Because of his ability to judge the value of so many forms of national activity, the engineer's greater participation as a citizen was urged. Excerpts from Doctor Skinner's speech follow.**

DURING the last year or two we have heard much in regard to the part our so-called machine age has played in bringing about this period of depression and unemployment. We hear talk of over-production, of under-consumption, of difficulties in distribution, of necessity for shorter working hours, and many other similar questions. Without attempting in any way to discuss or pass on these questions it does seem desirable to point out that these changes, bringing about mass production through standardization and the application of the power driven machine, are inevitable and must and will continue.

These things have been going on ever since the first application of power to displace handicraft at almost the beginning of the last century. We might speak of this as the inevitableness of change, and change will continue so long as more effective methods and machinery are developed. Development cannot be stopped by declaring a holiday on research and invention. . . .

At this point it should be remarked that equalization of rates, equal control of operation, and taxation so adjusted that the old service does not help to support the new to its hurt, will, of course, in the end be beneficial to all concerned. When broadly interconnected power systems, with their highly efficient generating stations, either steam or water, can furnish dependable electric power at a cost much below that of the small isolated plant, the small plant must be abandoned. When there is devised, as has already been done, a continuous rolling mill which receives an ingot at one end and without pause keeps this metal moving until it is rolled up as a continuous sheet at the other end, the older type of sheet mill requiring its intense human labor must give way to the new order. These and a multitude of other changes have been and are under way. What is necessary above everything else in connection with such changes is that we adjust ourselves to these changes, and that there be as little disturbance as possible to those elements which are of necessity affected or displaced. This first of all applies to the human element involved in each case. Our relatively high living standard should not only be maintained but increased and extended to all who do their part in production and distribution.

We should endeavor so to adjust our laws and regulations that new and competitive devices of merit are on an equitable basis with those which have preceded them. This adjustment in many cases may well take the form of easement of the burdens of the older facilities as well as such equitable control of the newer that each may find its proper sphere of usefulness without detriment to the other. Perhaps the outstanding example of the need of such equitable arrangement is found in our transportation systems today. The engineer above all others should stand for fair dealing based on deductions brought about through unquestioned fact finding, and it is the engineer above all others who by training and experience is in the best position to arrive at correct conclusions in connection with many of the problems with which we are faced.

We hear much at the present time of the necessity for increased taxation. We hear comparatively little of reduction in expenses, which could be brought about by more orderly conduct of our affairs. For many years engineers have advocated more effective coordination and correlation of the public works functions of the Government. The President, in his recent message to Congress, has advocated legislation to bring this about, and . . . it is hoped that a bill for this purpose now pending before Congress will be passed, if for no other reason than to accelerate public construction in periods such as those which we have been experiencing during the last two years.

In what has been said, I have hinted at some of the problems before us as engineers, and I wish particularly to emphasize our responsibilities as citizens as well as engineers, urging participation in those larger affairs which affect not only engineers but all citizens of our country and in which the engineer is in a peculiar position to guide and to lead.

C E Skinner

# The Power Age and Modern Civilization

**Although the moving powers of heat and electricity have raised man's physical existence to Olympian heights, they have not worked similar miracles in his spiritual life. Engineers and scientists are called upon to banish fear and hatred from the human heart by application of that greatest power of all —the power of love.**

By
M. I. PUPIN
Honorary Member A.I.E.E.

Columbia University
New York, N. Y.

FARADAY'S DISCOVERY of electromagnetic induction, a hundred years ago, is the closing event of a great epoch in the history of physical science and engineering. It is the epoch in which the power age was born.

Watt's invention of the steam engine marks the beginning of this epoch. It suggested to the genius of Carnot the immortal idea embodied in his well known law. This law defines what Carnot called the moving power of fire, that is of heat, a name which today is one of the greatest names in physical science.

Carnot's interpretation of the moving power of heat completed in 1824 the first great step in the evolution of the power age. The second great step was made when in 1820 Oersted discovered the magnetic force of moving electricity and a few years later Faraday discovered the electric force generated by moving magnetism. The law of action of these forces defined the moving power of electricity just as Carnot's law defined the moving power of heat. We know today that these two moving powers are the fundamental physical powers in the universe, and that their revelation was the greatest achievement ever recorded in the history of engineering sciences. It inaugurated, a hundred years ago, the power age. This age is the parent of our present civilization and the moving powers of heat and of electricity are the propelling powers in the physical evolution of this civilization.

Our civilization very often is called the machine civilization and what I call the power age often is called the age of machines. I don't like these names for the simple reason that machines are the creation of the hands of mortal man. They are transient, but the moving power of heat and the moving power of electricity are eternal; these powers are the immortal elements in the physical structure of our civilization.

Advancement of science during the power age, that is during the last hundred years, revealed that the same fundamental powers which are at work in the evolution of our civilization were also at work in the evolution of organic life ever since life appeared on this terrestrial globe and that they are also the only propelling powers in the evolution of the luminous stars. Radiations from these stars tell us that the moving powers of heat and of electricity are of celestial origin; they were brought to earth on the wings of solar radiation and remained dormant until the genius of Watt, Carnot, Oersted, Faraday, and Henry called them to the service of man. This service is the service of our central star to this tiny terrestrial globe; its mission on this earth recalls the mission of the celestial flame which, according to an ancient legend, the Titan Prometheus snatched from the radiant chariot of the sun god Helios and brought down to earth. The ancients believed that the mission of that celestial flame was to make the life of man similar to the life of the Olympian gods.

We believe that the mission of the moving powers of heat and of electricity, our most precious gifts from our central star, is to raise the life of man to Olympian heights. But has our civilization, the offspring of the power age, lived up to the lofty aim of this mission?

Two pictures occur to me when I attempt to answer that question—two entirely different pictures. In one of the pictures I see the triumphant conquest of space by the automobile and the aeronautical art. I see the wonders of power distribution increasing a hundredfold the comforts and the creative power of man, and I am thrilled by the electric waves which gliding over wires or wandering through space convey on their wings speech and melody over continents and oceans to every nook and corner of this terrestrial globe. These are a few of the miracles of our power age by which the moving powers of heat and of electricity have displayed the magic of their celestial origin; they certainly have made the physical side of human life even more glorious than the life of the Olympian gods. This achievement of the power age is its greatest glory.

But the spiritual side of human life, exhibited by another picture, is far from edifying. In this second picture we see desolation on every side in the wake of the most deadly war which the world has ever seen. The world appears here standing on the verge of economic collapse, and yet vast armies and navies are devouring the meager remnants of the wealth of nations while millions of idle workers are starving. The most repulsive figures in this horrible picture are fear and hatred, which, like two ugly demons, are hovering on each side of the boundary lines between neighboring nations.

Banish these demons from the human heart and there will be no need of vast armies and navies to guard our security against hostile neighbors; there will be no hostile neighbors, and wars will become a dying memory only of former barbarous ages. But the celestial ser-

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An address delivered by Doctor Pupin when the John Fritz Medal was presented to him at a special session of the A.I.E.E. winter convention on the evening of Jan. 27, 1932.

vants of our civilization, the moving powers of heat and of electricity, have not banished them.

Science admits that the magic of these two primordial powers cannot unaided purge the soul of man and eliminate the poisons which corrupt its spiritual life. Another moving power is sorely needed which can penetrate more deeply than the moving power of even the infinitely minute electrons into the depths of the human heart. This need was recognized nearly 2,000 years ago when our Saviour revealed the moving power in the spiritual world and commanded us to love the Lord our God, and to love our neighbors as ourselves.

This was a message of the approaching power age in the spiritual world. But this age has not yet arrived; mankind has not yet yielded to the greatest moving power in the spiritual world, and without its aid the moving powers of heat and of electricity cannot contribute their full share to the evolution of the spiritual life of man.

Love of the eternal truth and of their work to reveal this truth for the good of mankind has guided the scientists and engineers to the great triumphs of science. These triumphs of love will persuade the reluctant world that the victorious triumph of the moving power of love which Christ discovered will be the greatest triumph of the power age.

# A High Speed Relay for Short Lines

**A new high speed distance relay with composite impedance-reactance characteristic has been developed. This modification combines the mechanical simplicity of the impedance type relay having inherent possibilities for high speed of operation so desirable where stability is a factor, with, on the shorter lines, the greater independence of the reactance type relay from the effects of fault-resistance.**

By

S. L. GOLDSBOROUGH Westinghouse Elec. & Mfg. Co., Newark, N. J.
Associate A.I.E.E.

W. A. LEWIS Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Associate A.I.E.E.

TRANSMISSION of power over longer distances and the concentration of greater amounts of power over a single circuit have rendered the presence of a short circuit on the system a more serious matter, and a considerable effort therefore has been made to reduce the duration of the short circuits. The result has been the development of circuit breakers and relays operating to clear the disturbance in a very short time. The conventional type of induction overcurrent relaying, depending upon successively increasing time intervals to obtain proper selectivity between circuit breakers, is no longer suitable where the maximum speed is desired; and so a new form of relaying, known as distance relaying, has been developed for the general protection of transmission and distribution lines. Relays operating on the distance principle make use of the characteristic impedance or reactance of the circuit, as determined by comparing the voltage and current at the relaying point, to determine the distance from the relay to the fault. Hence, selectivity between circuit breakers can be obtained without the use of increasing time intervals in the time settings of relays as the generating station is approached.

The tripping-time characteristic employed with the new types of distance relays is shown in Fig. 1. When a fault occurs between station *A* and the point *m* the relay trips instantaneously. When a fault occurs between the point *m* and the point *n*, a time delay $t_1$ purposely is introduced in the relay at *A*. If the fault is between station *B* and the point *n*, the time delay introduced in the relay at *A* will allow the relays at *B* to trip the circuit breaker at *B* first, so the relay at *A* resets and does not trip its breaker. If, on the other hand, the fault is between *m* and *B* the breaker at *A* will be tripped after a time delay $t_1$. It is customary also to provide a third range of protection which will trip the circuit breaker at *A* after a time interval $t_2$, for a fault at any location between station *A* and the point *p*, if it is not cleared earlier by the action of other relay elements.

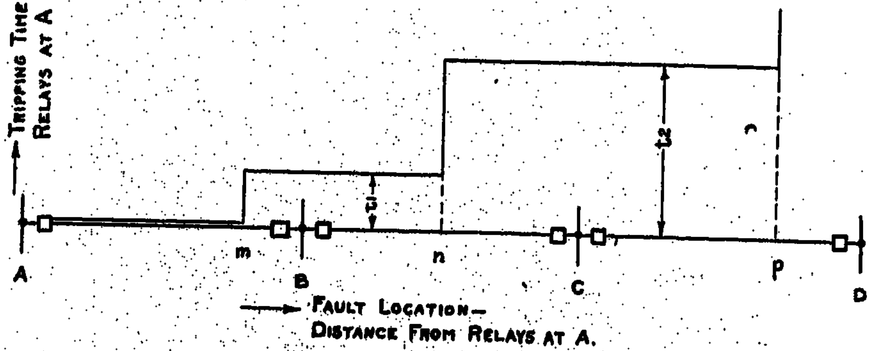

Fig. 1. Distance-time characteristic of "balance point" distance relays

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Based upon "A New High Speed Distance Relay" (No. 32M1) presented at the A.I.E.E. winter convention, New York, N.Y., Jan. 25-29, 1932.

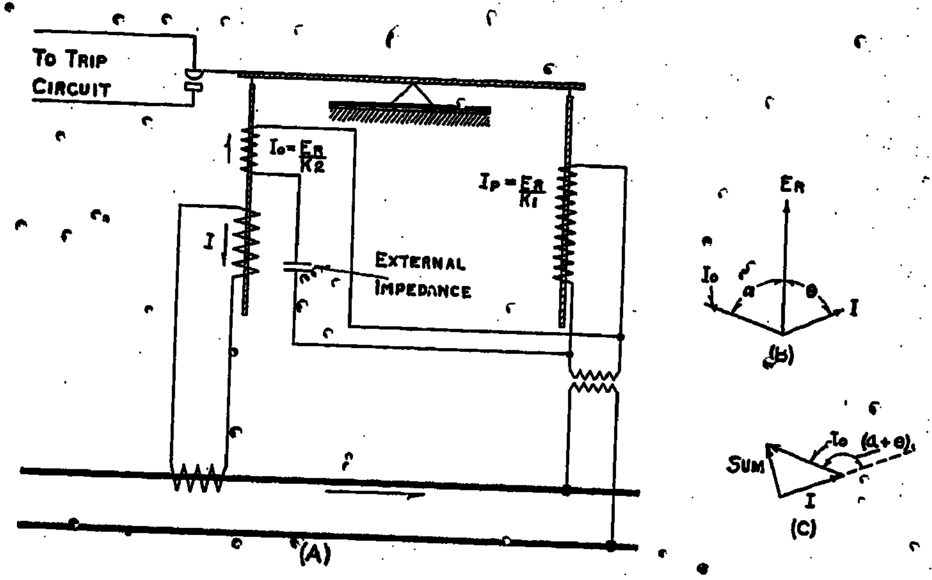

Fig. 2. Schematic diagram of new modified relay

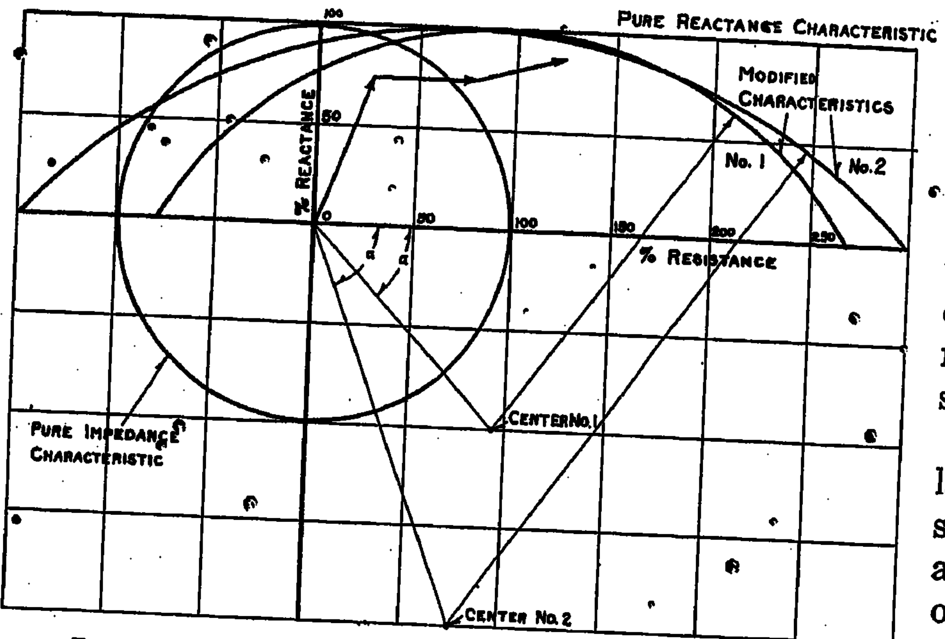

Fig. 3. Tripping characteristic of modified relay

Two general types of relays having the same time characteristics have been developed. These two types are impedance relays and reactance relays, the first of these operating on the impedance of the line between the relay and the fault, and the second on the reactance alone. Each of these types has advantages, but is subject also to certain disadvantages. The new relay described here combines the principal advantages of both of these types.

The new relay is essentially a modification of the simple balanced-beam impedance relay, as may be seen from Fig. 2. The impedance relay consists essentially of the balanced beam supporting two plungers. On one side of the relay a current coil acts to close the relay contacts and on the other side a potential coil acts to hold the contacts open. The modification, which gives the new relay its desirable characteristics, consists in the addition of a second voltage coil to the current side of the relay.

The simple impedance relay with one voltage coil and one current coil will balance when the pull of the current coil just balances the pull of the voltage coil. If the current pull increases the relay will operate to close the contacts to the trip circuit. The pull will just balance when the ratio of voltage to current is a definite constant, depending upon the design and adjustment of the relay. This constant ratio will be equal to an impedance, since impedance equals voltage divided by current. For all smaller values of impedance, the current pull will exceed the voltage pull and the relay will operate, whereas for all larger values of impedance the relay will not operate. This characteristic is shown graphically in Fig. 3 by the circle marked "pure impedance characteristic." In this figure per cent resistance is plotted along one axis and per cent reactance along the other. When the impedance is 100 per cent, the values of resistance and reactance plotted in this diagram will give a circle about the origin with 100 per cent impedance as a radius. Thus the relay trips for points lying within the circle, and does not trip for points lying outside of the circle.

The addition of the second potential coil on the current side of the relay does not change the fundamental circular characteristic of the relay, but, when plotted in the same form, has the effect of shifting the center of the circle and changing its radius. The new location of the center and the new value of the radius will depend upon the effectiveness of the second potential coil as well as on the phase angle of the current through this coil with respect to the current in the main current coil. Two such modified characteristics are shown in Fig. 3.

With the simple impedance relay, the presence of a large amount of accidental fault resistance, as may sometimes occur on relatively short lines, may cause the apparent impedance as measured by the relay to fall outside of the characteristic circle, when the impedance of the line alone, between the relay and the point of fault, would fall within the characteristic circle. For such cases the proper element of the relay would be prevented from tripping. The modified characteristics as shown in the figure greatly increase the area within which the relay will trip and thus overcome this difficulty.

A relay operating on a pure reactance characteristic, that is, one designed to trip for all values of reactance up to a given value, regardless of the fault resistance, would also largely overcome this difficulty. However, the apparent reactance of high power factor loads existing before the short circuit would be very low, so that such a relay would trip under load conditions unless prevented from doing so by auxiliary devices. It is difficult to give the auxiliary devices the exact characteristics needed, and in addition some time delay is introduced by their operation, which is undesirable where high speed of fault clearing is an important factor. The modified-characteristic relay overcomes this disadvantage also because the circular characteristics intersect the resistance axis at values of resistance which will prevent operation of the relay under the heaviest loads.

The manner in which this characteristic is used to obtain the desired tripping-time characteristic illustrated in Fig. 1 is shown in Fig. 4. Three distance measuring elements are used in the complete relay, the first tripping the circuit breaker instantaneously, the second and third elements operating through an adjust-

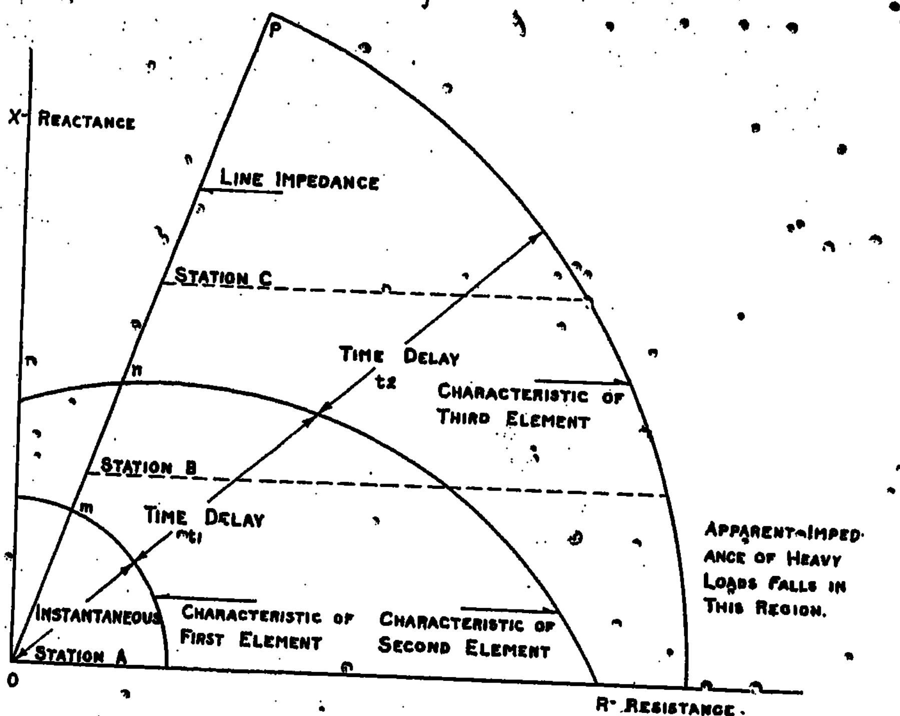
X- Reactance
P
Line Impedance
Station C
Time Delay
t2
Characteristic of Third Element
n
Station B
m
Time Delay
t1
Apparent Impedance of Heavy Loads Falls in This Region.
Instantaneous
Characteristic of First Element
Characteristic of Second Element
Station A
0
R- Resistance

Fig. 4. Approximate characteristics of relay

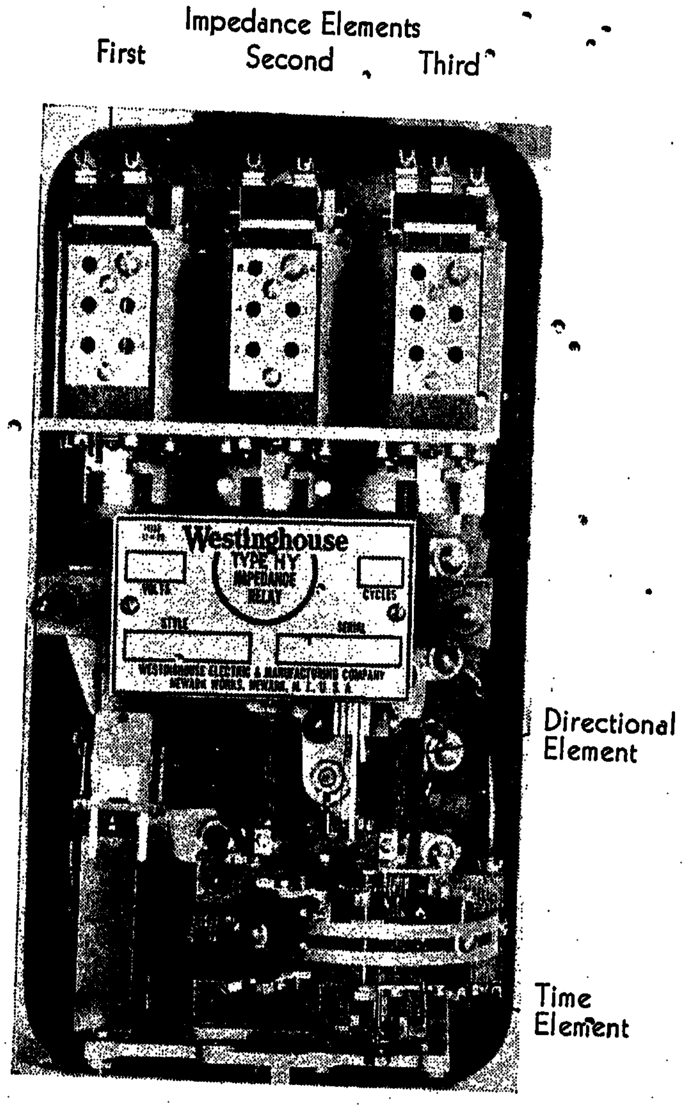

Fig. 5. New relay with modified characteristic

able timer to interpose the necessary adjustable time delays $t_1$ and $t_2$. Tests have shown that arc resistance is generally quite small at the inception of the fault, but that it may increase to rather large values if the arc is allowed to persist. This indicates that in the first zone in which the relay is designed to trip instantaneously the error in distance measurement due to the effect of arc resistance will not seriously affect the operation of the relay, so that the simple impedance element may be used. However, in the second zone of the relay, such as between $m$ and $n$ in Fig. 1, where a definite time purposely is introduced into the operation of the relay, the arc resistance may increase to important values. Hence, on the shorter lines, the arc resistance may become large enough in comparison with the impedance of the line section to affect the operation of the relay, and the use of the modified characteristic as shown in Fig. 4 is indicated for the second distance element of the relay. The third distance element is provided for back-up protection only, and may be set to balance for faults so remote that the arc resistance will not affect its operation. Hence, a pure impedance element may likewise be used for the third element. Thus, referring to Fig. 4, for a fault between $m$ and station $B$, where a time delay $t_1$ is required, values of fault resistance considerably in excess of the impedance of the section may be permitted without affecting the performance of the relay in any way.

The complete relay is shown in Fig. 5. In addition to the three distance elements and the timer already mentioned, there is included a sensitive directional element to insure that the relay will trip only when the fault is in the proper direction from the relay.

Mechanically the three distance measuring elements are duplicates. However, on the second element the voltage coil on the current side is provided in order to obtain the desired modified characteristic. The voltage side of each element is provided with two voltage coils, instead of the single coil indicated in Fig. 2, in order to prevent chattering and the tripping of the beam during the period when the voltage is going through zero. These two coils have separate cores but are so arranged that the beam completes the magnetic circuit in each case, and the fluxes in the two cores are shifted in phase from each other so that a practically constant voltage restraint is produced.

The timing element consists of a small floating-armature synchronous motor driven from a small saturating current transformer. The motor drives a bridging contact through suitable reduction gears so as momentarily to bridge two sets of stationary contacts which can be shifted independently on a scale in order to vary the timing. The motor normally is prevented from operating by a normally closed contact on the third or back-up distance element of the relay, which of course operates for all faults within the range of the relay. The maximum time is adjustable up to approximately 3 sec.

The directional element is of the pure wattmeter type and consists of a rectangular aluminum loop which acts as the short-circuited secondary of a small potential transformer and rides in a magnetic field produced by two current coils. Motion about the pivoted axis of the loop thus is produced and the direction of the motion is dependent upon the relative polarity of the current and voltage.

The new relay is intended for application to the shorter line sections, where the arc resistance may reach comparatively large values, for protection against line-to-line, double line-to-ground and three-phase faults. To prevent differences in the distance measurement depending upon the type of fault, the current windings of the relay should be connected to utilize the difference between the currents flowing in the two line conductors to which the relay is assigned, and not the current in a single line, since the latter would produce errors amounting to 15 per cent or perhaps even more depending upon which of the types of fault occurred.

The factor which limits the length of line to which the relay can be applied is the requirement that the element with the composite characteristic must not operate on load currents. The longer the line the greater is the possibility of this occurring, and for the particular characteristic discussed, the limit is approximately 2 ohms, measured in terms of the secondary voltages and currents applied to the relay.

The principle employed in the new relay is particularly valuable in that it imparts a wide flexibility to the distance measuring characteristics. Where necessary, it can be applied to any one or all of the three elements and practically any sort of characteristic which experience may indicate to be desirable can be obtained by proper choice of characteristics for the auxiliary coil.

# Generator Overvoltage when Dropping Load

Sudden dropping of load tends to result in overvoltage of generators. Tests show definitely that such overvoltage can be prevented by the use of high speed regulators and bridge type field rheostats, or by inserting resistance automatically in the generator field circuit.

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TOTAL or partial loss of load on waterwheel-driven generators or hydroelectric stations frequently results in undesirable voltage rise, and in such cases it is desirable to limit this voltage rise in order to avoid overstressing the insulation of generators and connected apparatus.

In the past this sometimes has been accomplished by use of overvoltage, overspeed, or overfrequency relays which automatically open the field circuit and trip the generator from the line or bus when the voltage or speed reaches a predetermined value. This is a very effective way of limiting the overvoltage, but it has the disadvantage of making necessary the resynchronization of the different machines in a station, to get them back into service.

In an earlier article ("Over-Voltage on Transmission Systems Due to Dropping of Load," A.I.E.E. TRANS., 1925, V. 44, p. 872-80) was shown the manner in which under various conditions transmission line voltage will rise as a result of load dropping. The purpose of this paper is to show how the voltage on a waterwheel generator or hydroelectric station may be held within reasonable limits at a time when full load is suddenly lost, without opening the field circuits of the machines or tripping them from the line or bus.

Information given is based upon the results of tests made on a 47,000-kva. generator at the Spier Falls plant of the New York Power and Light Corporation. In these tests use was made of a newly developed high speed generator voltage regulator and a wheatstone bridge type of main exciter field rheostat which made possible the quick reduction of generator field current thereby limiting the generator voltage. Tests were made also upon the same generator to show the possibilities of limiting generator voltage by automatically inserting resistance in the alternator field.

In Fig. 1 is given a simplified diagram of the test connections used including a six-element oscillograph. The main exciter is compound wound, but as tests were desired for a shunt wound exciter, a switch was arranged to insert an 0.08-ohm resistor in the alternator field circuit to change the time constant of the circuit to a value simulating that of a shunt wound main exciter. There being no low voltage bus or circuit breaker, load always was dropped in the tests by tripping the transformer high voltage circuit breaker.

## REGULATOR EQUIPMENT

The wheatstone bridge rheostat shown in Fig. 1 is suitable where it is desirable to reduce the main exciter voltage to a very low value or reverse it, or when the very quick reduction of exciter voltage is desirable, as in the case under consideration.

Arms marked *A* are operated simultaneously by motor *M*. Arms marked *B* are operated simultaneously by a handwheel to give the desired voltage reduction when the high speed relays *X* open. In the case under consideration a setting was made such that when relays *X* opened, the main exciter armature voltage was reduced to a negative value of approximately 10 volts.

The primary control element, Fig. 2, of the high speed regulator used consists of a three-phase torque motor, to the rotor of which are attached two pairs of contacts. Of these, both front and rear make contact with disks connected to a shaft driven at constant speed by a

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Based upon "Overvoltage on Transmission Systems Caused by Dropping Load" (No. 31-140) presented at the A.I.E.E. South West District meeting, Kansas City, Mo., Oct. 22-24, 1931.

small a-c. motor. The front disk has cam shaped teeth while the rear disk is smooth.

This regulator remains inoperative with both pairs of contacts out of engagement as long as no change in excitation is required. For slight changes in voltage only the front contacts $L_1$ and $R_2$ and the motor operated field rheostat are affected, a "notching" action resulting varying from a single brief impulse to practically continuous operation of the motor depending upon the correction required. Only for greater changes in voltage do the back contacts $L_2$ and $R_2$ and the high speed relays $X$ and $Y$ come into action to maintain the voltage until the motor operated rheostat has moved to a position corresponding to the required excitation.

The notching action of the front contacts in conjunction with the intermittent operation of the rheostat prevents overtravel of the latter with consequent hunting. The back contacts go into operation when the a-c. voltage has changed from 3 to 15 per cent, according to the adjustment made. The regulator will hold constant voltage for all frequencies between 25 and 85 cycles.

## RESISTANCE IN FIELD CIRCUIT

In Fig. 3 are indicated the connections and devices used to insert resistance automatically in the alternator field circuit upon the occurrence of overvoltage. The contact making voltmeter type of overvoltage relay endeavors to hold a-c. voltage in accordance with its setting by repeatedly opening and closing a contactor connected across a resistor in the alternator field circuit. As soon as the contactor opens, the setting of the overvoltage relay may be changed if desired to hold normal voltage or a voltage of some predetermined value. This change in the setting of overvoltage relay is accomplished by the use of a hand reset relay which, upon closing its contacts, changes the value of resistance in the coil circuit of the overvoltage relay. In the case under consideration the overvoltage relay was set to operate at approximately 16.8 kv. or 22 per cent above normal voltage.

## TEST RESULTS

Results of dropping load on the 47,000 kva. generator under the conditions mentioned are shown in Figs. 4, 5, and 6. When load was dropped, there were two or three cycles of single-phase operation caused by the three poles of the 110-kv. circuit breaker not opening at exactly the same moment. Because of this it may be noticed that the alternator field current did not decrease instantaneously at zero time, but dropped to its new value in about three cycles, which is reasonable when it is considered that it took that time to drop the load completely. In all cases where a 40,000-kw. load was dropped, a maximum of 138 per cent of normal speed was reached in approximately 3.5 sec.

Referring to Figs. 4 and 5, approximately 4 per cent higher alternator voltage was obtained with the compound than with the shunt connected main exciter when a 40,000-kw. load was tripped, using the wheatstone bridge arrangement. Also, with the shunt exciter the overvoltage was reduced more quickly than with the compound exciter. When using the shunt exciter the maximum voltage was 16.5 kv. or approximately 20 per cent above normal, and for the compound exciter, 17.2 kv. or approximately 25 per cent above normal. This shows very clearly the effectiveness of the regulator with the wheatstone bridge arrangement because with no regulator the alternator voltage would have reached 180 per cent of normal value when tripping the

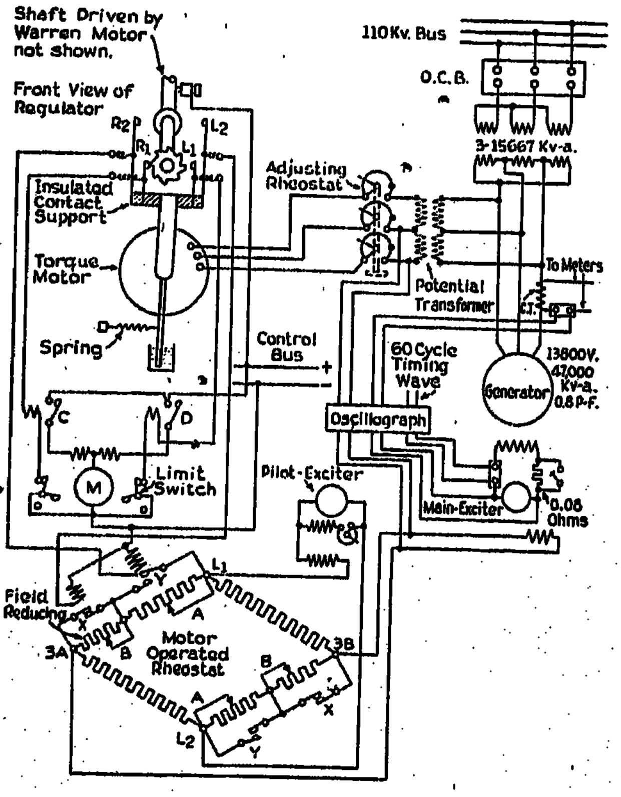

Fig. 1. Connections for tests at Spier Falls station

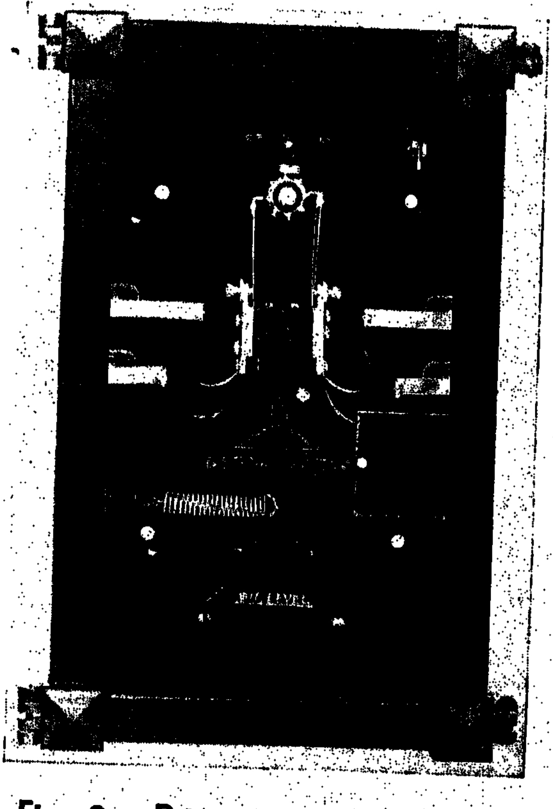

Fig. 2. Primary control element of high speed regulator

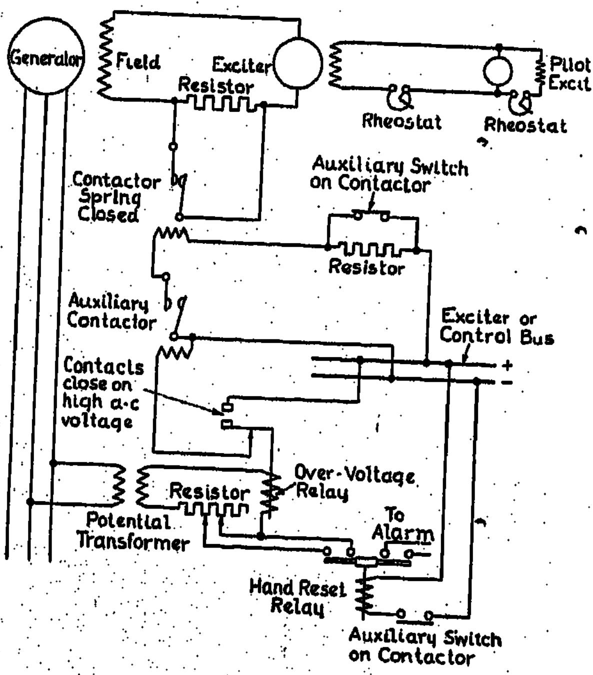

Fig. 3. Method of automatically inserting resistance in alternator field circuit upon occurrence of overvoltage

transformer high voltage circuit breaker and dropping a 40,000-kw. load of 0.9-power factor. Without the effect of transformer magnetizing current as would be the case if load were tripped on the low voltage side of the transformer, the alternator voltage would reach double value with no regulator or voltage limiting means.

What may be accomplished in limiting alternator voltage by automatically inserting resistance of 1.12 ohms in the alternator field circuit when dropping a 40,000-kw. load of 0.9-power factor is shown in Fig. 6. In this test the overvoltage relay shown in Fig. 3 was set to operate at 16.8 kv., and it held this value. It may be noticed that the maximum alternator voltage reached was 17.7 kv., or approximately 128 per cent of normal. In attempting to hold a-c. voltage the overvoltage relay opened and closed the contactor connected across the 1.12-ohm resistor in the alternator field circuit, giving the sudden increases and decreases in alternator voltage. This operation continued until the regulator could gain control, and lower the a-c. voltage to a point where the overvoltage relay would not operate. This was accomplished at the end of approximately 10 sec., as shown by a high speed voltage chart record. At that point, the regulator, which had been doing all it could to reduce the excitation, finally gained control and brought the voltage back to normal in about another 5 sec. The rather long time which elapsed before the regulator gained control was due to the use of a series rheostat instead of the wheatstone bridge arrangement.

## Conclusions

The tests described indicate that a suitable regulator and wheatstone bridge type of exciter field rheostat set to give zero or slightly negative main exciter armature voltage provide a simple means of limiting overvoltage caused by dropping load. Under ordinary conditions such equipment functions as required to hold normal a-c. voltage, but at the same time is ready to prevent the voltage from reaching dangerous values which would overstress the insulation of generators and connected apparatus. Furthermore, the use of such equipment has made possible the design of lightning arresters and protective apparatus to give better protection and at the same time not be subject to failure on overdynamic voltage.

The alternative method of automatically inserting resistance in the alternator field circuit also is very effective in keeping the a-c. voltage within desired limits when load is lost. Therefore, this method is available for use where overvoltage protection is needed and there are no generator voltage regulators; or where regulators are being used, but the excitation system is of the older type and it is neither desirable nor economical to change the exciter field circuit to include such equipment as the wheatstone bridge.

In the tests described, load was dropped by tripping the transformer high voltage circuit breaker and therefore the effect of line charging current was not included. The effect of charging current is to give a higher value

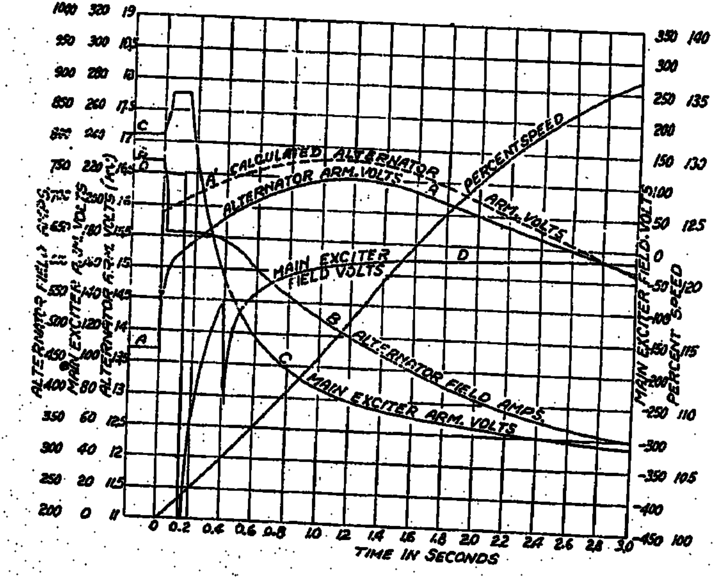

Fig. 4. 40,000-kw. load of 0.9-power factor dropped, using wheatstone bridge rheostat and shunt exciter

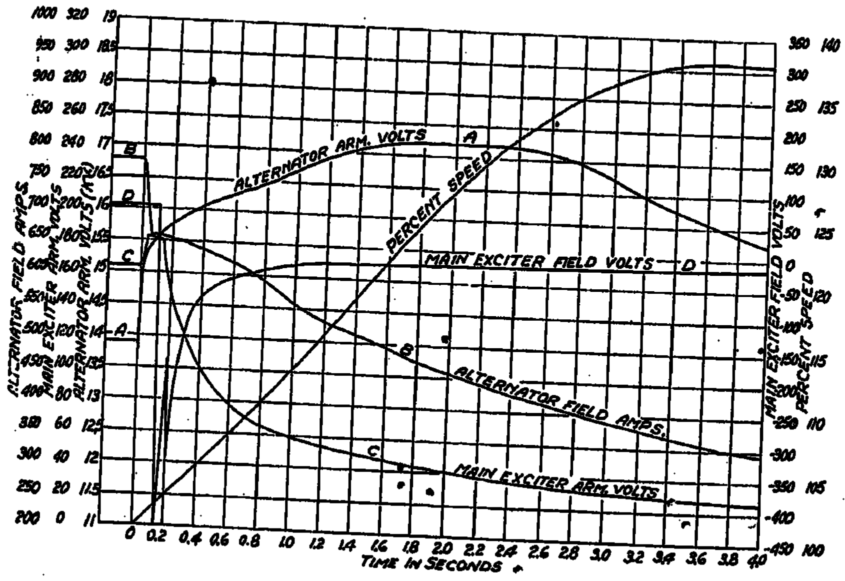

Fig. 5. 40,000-kw. load of 0.9-power factor dropped, using wheatstone bridge rheostat and compound exciter

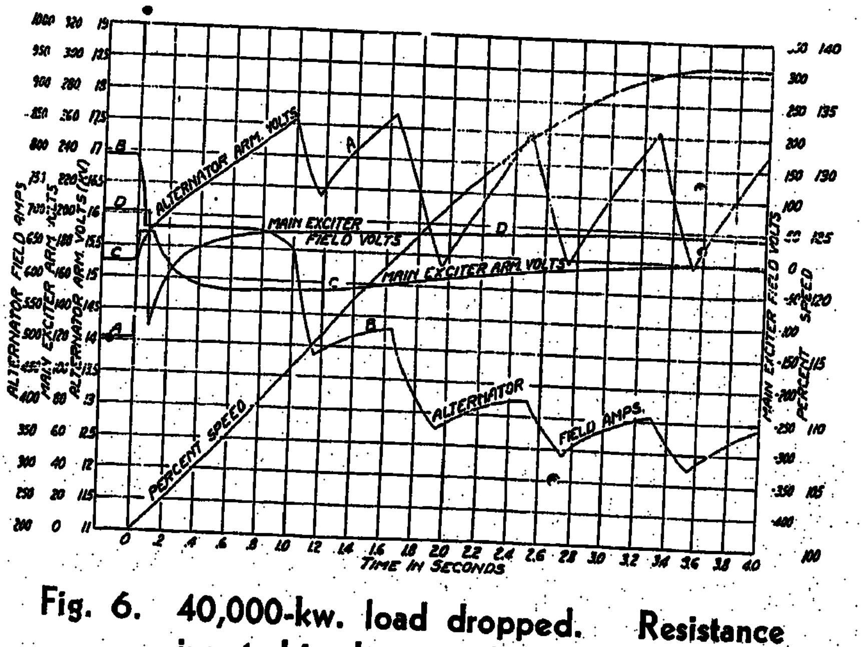

Fig. 6. 40,000-kw. load dropped. Resistance inserted in alternator field circuit

of voltage, the amount varying with the length and voltage of the line and the number of generators and transformers connected after load is lost.

Curve $A^1$ in Fig. 4 shows that it is possible to calculate very closely the overvoltage on generators caused by the dropping of load. The method of this calculation is described in the companion article immediately following.

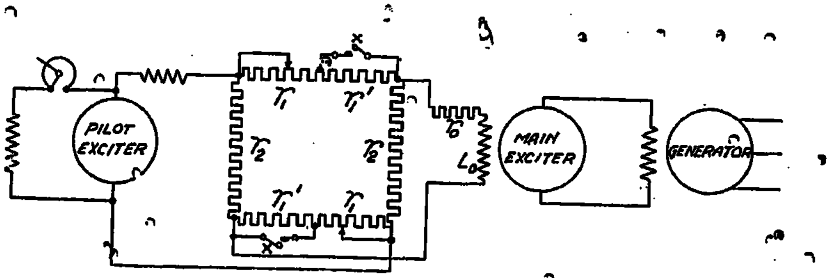

Fig. 1. Schematic diagram of excitation circuits using wheatstone bridge type rheostat

# Calculation of Generator Overvoltage

**Following the sudden loss of load by an alternator, speed and terminal voltage tend to increase rapidly. In the following article, a method is outlined for predetermining such overvoltage, with especial reference to waterwheel generators. Test results which have been obtained on an actual machine prove that the curve of overvoltage which may be calculated by this method closely follows that secured in practise.**

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CALCULATION of dynamic overvoltage of alternators following the sudden dropping of load is a subject that as yet has not been covered very extensively. The predetermination of the extent of such overvoltage is very desirable, however, in that it enables the necessary precautions to be taken to guard against the disadvantages which may result from voltages greater than normal. These may be especially serious in waterwheel generators. The method of calculation outlined applied especially to this type of unit, and allows the alternator terminal voltage to be expressed in terms of time subsequent to the loss of load. Test results which have been obtained on a 37,500-kw. machine prove the accuracy of the calculated results.

The factors influencing this type of overvoltage are overspeeding of the units, and the action of the generator voltage regulators. The major portion of overvoltage subsequent to loss of load is contributed by the increase in speed of the generator itself rather than by the increase in excitation due to overspeeding of the exciters. As a result, simplifying assumptions may be made relative to the exciter characteristics without appreciably affecting the accuracy. Assumptions used in this article and applying to the pilot exciter are as follows:

1. The time constant of the pilot exciter shunt field is so small as compared to the equivalent time constant of the speed-time curve that the shunt field current follows the speed exactly.
2. The load saturation curve of the pilot exciter coincides with the no-load saturation over the operating range. This is approximately true for pilot exciters that are flat-compounded and liberally designed.

Assumptions applying to the main exciter are:

1. Shunt wound main exciters will be considered, as shunt windings are generally believed to have the better characteristics and are commonly used at the present time.
2. The inductance of main exciter field circuit remains constant, but is corrected by a factor, depending upon the type of field structure.
3. The open circuit instead of the load saturation curve of the main exciter is used.

These last two assumptions compensate in a measure for the effect of the voltage coming down on a higher curve than the saturation curve, due to eddy currents when the field current decreases rapidly.

Heaviside's operational calculus is used in the analysis. The multiplier 1 appearing in the operational form of eqs. 1, 2, 4, 6, and 7, is called Heaviside's unit function. It is used in the derivations of his formulas, and even if it is not written down, it is tacitly assumed to be present. Generally speaking, it means that the action begins at $t = 0$ and time cannot be counted backward; that is, negative values of time cannot be used. The symbol $p$ is the Heaviside operator, which replaces $\frac{d}{dt}$ wherever it appears in the differential equations. An explanation of these terms as well as the steps involved in solving these differential equations to obtain eqs. 3, 5, and 8, is given in various texts. "Operational Circuit Analysis" by V. Bush, and "Heaviside's Operational Calculus" by E. J. Berg are especially recommended. However, if it is desired to work out a particular problem without going into it deeply, eqs. 3, 5, and 8 may be used without studying either their origin or Heaviside's operational calculus.

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Especially written for ELECTRICAL ENGINEERING and including the information given in the appendix to "Overvoltage on Transmission System Caused by Dropping Load" (No. 31-140) presented at the A.I.E.E. South West District meeting, Kansas City, Mo., Oct. 22-24, 1931.

### PILOT EXCITER ARMATURE VOLTAGE

With the assumptions previously outlined, the curve of pilot exciter armature voltage readily may be obtained as follows: From the saturation curve of the pilot exciter at normal speed, saturation curves for 110-per cent, 120-per cent, etc., speed may be drawn. Then drawing in the $RI$ line (product of field resistance and field current) as indicated on Fig. 2, the voltage for each speed is read as the intersection of the $RI$ line and the saturation curve for the particular speed.

A curve ordinarily may be obtained from the water-wheel manufacturer giving the speed of the unit upon sudden loss of load as a function of time; hence, by using the values of voltage for different speeds in conjunction with this speed-time curve, a voltage-time curve may be drawn. An empirical expression for this pilot exciter voltage-time curve in operational form using one exponential is

$$e_1 = a + \frac{b-a}{T_1p+1}\,1 \qquad (1)$$

where

$a$ = initial value of voltage

$b$ = final value of voltage

$$p = \frac{d}{dt}$$

and

$$\text{the time constant } T_1 = \frac{t_o}{\log_\epsilon \dfrac{b-a}{b-e_o}}$$

$e_o$ and $t_o$ are the coordinates of a particular point on the curve. It is preferable to take a point in the region where the greatest accuracy is desired.

### MAIN EXCITER FIELD CURRENT

The next step is to determine the main exciter field current considering regulator action on the bridge rheostat, and overspeeding of the pilot exciter. The excitation circuits, employing the wheatstone bridge type rheostat, are shown on Fig. 1. The method will be developed for this type of rheostat, but it is obvious that the method of attack would be the same for other types of control. The application and operation of the bridge type of rheostat are described in the companion article "Generator Overvoltage When Dropping Load" by E.J. Burnham, immediately preceding.

e voltage $e_1$ operates upon the bridge circuit, in $r_o$ and $L_o$ are the shunt field resistance and inducrespectively and $r_1$, $r_1'$ and $r_2$ are the rheostat re- Upon indication of overvoltage, the regulator cts $x$ inserting both blocks of $r_1'$ in the cir- alue of $r_1'$ usually is sufficient to reverse the

Consider the case when the regulator fails to operate. The current through the main exciter field will be

$$i_o = \frac{a\,(r_2-r_1)}{2\,r_1r_2 + r_o\,(r_2+r_1)} + \frac{r_2-r_1}{2\,r_1r_2 + (r_o+pL_o)(r_2+r_1)} \times \frac{b-a}{T_1p+1}\,1 \qquad (2)$$

The solution of which is

$$i_o = \frac{a}{m} + \frac{b-a}{nT_1}\,(A_o + A_1\epsilon^{-a_1t} + A_2\epsilon^{-a_2t}) \qquad (3)$$

where

$$m = \frac{2\,r_1r_2 + r_o\,(r_2+r_1)}{r_2-r_1} \qquad n = \frac{L_o\,(r_2+r_1)}{r_2-r_1}$$

$$A_o = \frac{1}{a_1a_2}$$

$$A_1 = \frac{1}{-a_1\,(a_2-a_1)} \qquad a_1 = \frac{m}{n}$$

$$A_2 = \frac{1}{-a_2\,(a_1-a_2)} \qquad a_2 = \frac{1}{T_1}$$

The contacts $x$ are opened by a voltage regulator in 3 cycles after the indication of 5 per cent overvoltage. This overvoltage will appear the instant load is lost. Due to the quick action of the regulator and the time constants of the circuits involved, it can be assumed with very little error that the loss of load and opening of the contacts $x$ occur simultaneously.

Hence, the equation for the current after the regulator acts can be written

$$i_o = \frac{a\,(r_2-r_1)}{2\,r_1r_2 + r_o\,(r_2+r_1)} - 2\left[\frac{a\,(r_2+r_o)}{2\,r_2r_1 + r_o\,(r_2+r_1)} \times \frac{r_2r_1}{2\,r_2\,(r_1+r_1') + (r_o+pL_o)\,(r_2+r_1+r_1')}\right]1$$

$$+\frac{r_2-r_1-r_1'}{2\,r_2(r_1+r_1')+(r_o+pL_o)(r_2+r_1+r_1')} \times \frac{(b-a)}{T_1p+1}\,1$$

The solution being (4)

$$i_o = Y_1 + Y_2\epsilon^{-a_2t} + Y_3\epsilon^{-a_3} \qquad (5)$$

where

$$Y_1 = \frac{b\,(r_2-r_1-r_1')}{2\,r_2\,(r_1+r_1') + r_o\,(r_2+r_1+r_1')}$$

$$Y_2 = \frac{(r_2-r_1-r_1')\,(b-a)}{L_o\,(r_2+r_1+r_1')\,(a_2-a_3)}$$

$$Y_3 = \frac{(r_2-r_1-r_1')(b-a)}{[2\,r_2\,(r_1+r_1') + r_o\,(r_2+r_1+r_1')]\,[(T_1\,a_3-1)]} + \frac{2\,a\,(r_2+r_o)\,r_2r_1'}{[2r_2r_1+r_o(r_2+r_1)][2r_2(r_1+r_1')+r_o(r_2+r_1+r_1')]}$$

$$a_3 = \frac{2 r_2 (r_1 + r_1')}{L_o (r_2 + r_1 + r_1')} + \frac{r_o}{L_o}$$

$$a_2 = \frac{1}{T_1}$$

Thus eq. 5 gives main exciter field current considering regulator action on the bridge rheostat and overspeeding of the pilot exciter. This current flowing through the main exciter shunt field produces main exciter armature voltage and current which will now be considered.

## MAIN EXCITER ARMATURE VOLTAGE AND CURRENT

By plotting eq. 5, the curve of main exciter armature voltage can be determined, considering the increase in speed, as follows: For any particular value of $i_o$ flowing at time $t$ the voltage is read from the saturation curve (taken at normal speed). From the speed-time curve of the unit, the speed of the set can be read for the particular time $t$ chosen, and the voltage increased in direct ratio. The voltage function thus obtained is that which operates upon the generator field. The operational equation of such a curve, similar to that of eq. 1, is

$$E = E_o - \frac{E_1}{T_2 p - 1} 1 \qquad (6)$$

where

$E$ = main exciter armature voltage

$E_o$ = voltage before loss of load

$E_1$ = increase in main exciter armature voltage (final value minus the initial value $E_o$)

$T_2$ = time constant obtained from main exciter armature voltage-time curve

The problem now is to find an equation of generator field current as a function of time. Having this, generator terminal voltage for any value of field current can be read directly from the saturation curve and corrected for the increased speed at the particular time chosen.

There are two factors affecting the generator field current. Upon sudden loss of load, the field current drops immediately to a value necessary to produce flux back of transient reactance. It then builds up to a value that existed before loss of load, according to the open circuit time constant of the generator field circuit, and provided constant slipring voltage is maintained. But in this case under consideration, due to the regulator action and increased speed of exciters, the slipring voltage varies according to eq. 6.

With the voltage expressed by eq. 6 applied to the sliprings, and considering the drop of current at $t = 0$, the following type of equation for generator field current will result:

$$I = I_o - I_o' \frac{p}{T'_{do} p + 1} 1 + \frac{E_1}{r} \frac{1}{(T_2 p + 1)(T'_{do} p + 1)} 1 \qquad (7)$$

The solution being

$$I = I_o - I_o' \epsilon^{-c_1 t} + I_1 (C_o + C_1 \epsilon^{-c_1 t} + C_2 \epsilon^{-c_2 t}) \qquad (8)$$

where

$I_o$ = field current before loss of load

$I_1 = \frac{E_1}{r T_2 T'_{do}}$

$T'_{do}$ = open circuit time constant of generator

$r$ = resistance of field circuit

$I_o'$ = the decrease in field current the instant load is lost. This calculation is explained under the heading "Calculations for Instant of Dropping Load" following.

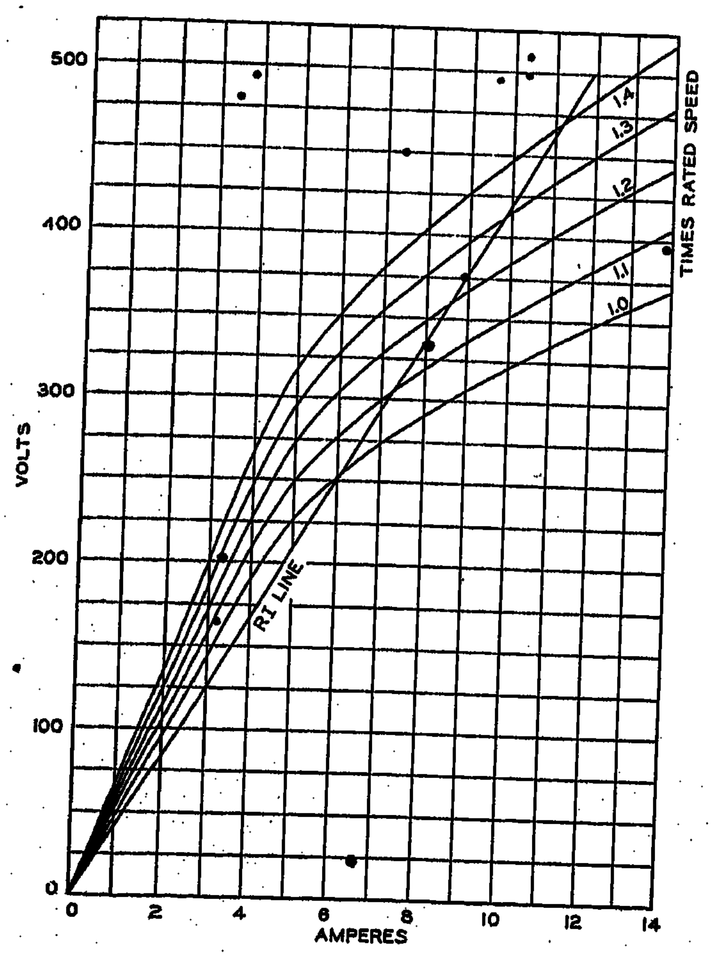

**Fig. 2.** Pilot-exciter saturation curves for various speeds

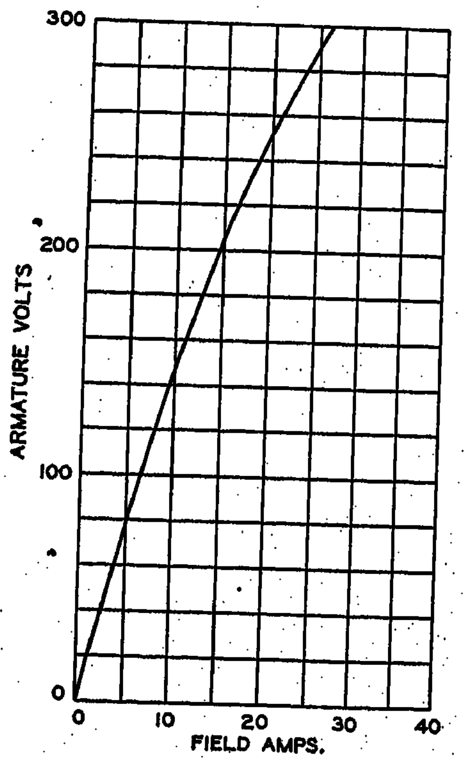

**Fig. 3.** Main-exciter saturation curve

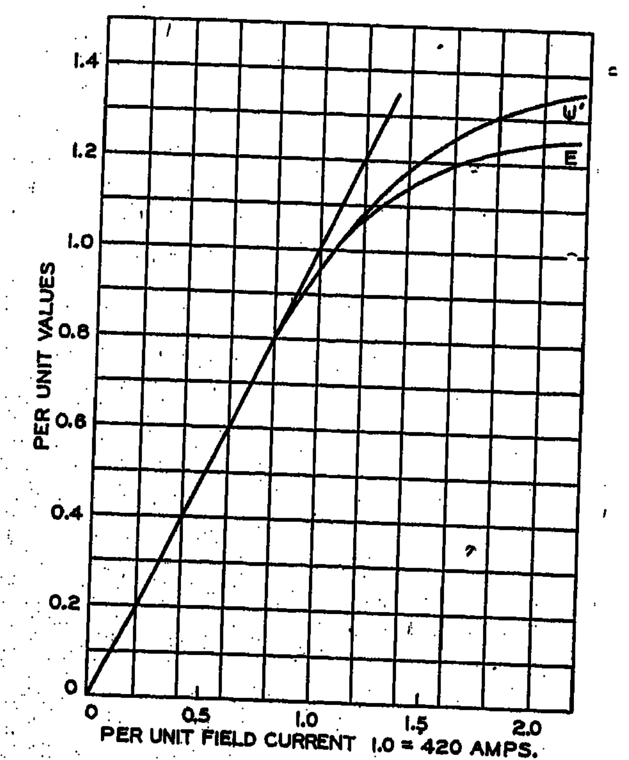

**Fig. 4.** Calculated linkage and voltage saturation curves of generator

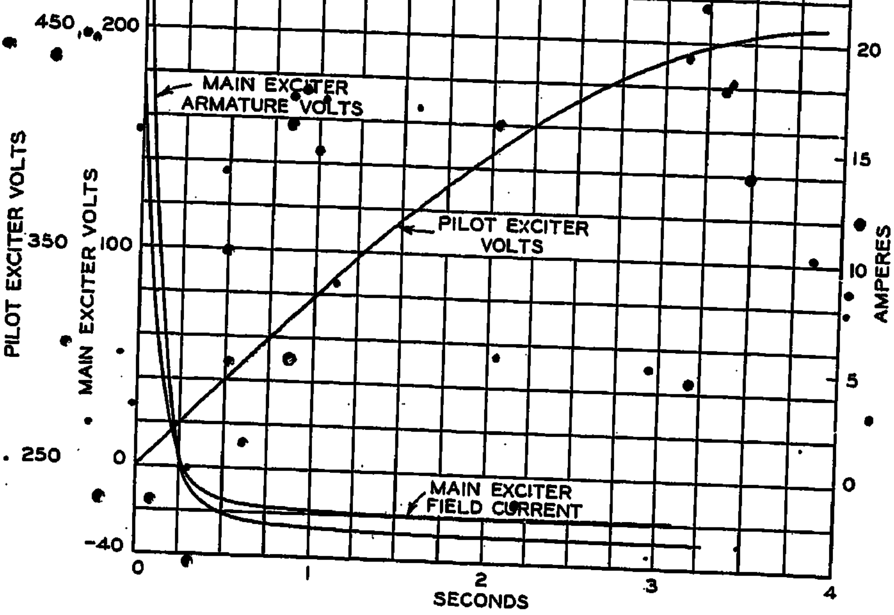

Fig. 5. **Exciter characteristics**

$$C_o = \frac{1}{c_1 c_2}$$

$$C_1 = \frac{1}{-c_1(c_2 - c_1)} \qquad c_1 = \frac{1}{T'_{do}}$$

$$C_2 = \frac{1}{-c_2(c_1 - c_2)} \qquad c_2 = \frac{1}{T_2}$$

After plotting eq. 8, the curve of generator terminal voltage can be determined by using the generator saturation curve and speed-time curve as was explained for main exciter armature voltage. This completes the calculation for conditions at the generator terminals. Although quite involved, and not covered in this article, the same method can be extended to include a long transmission line remaining connected after load is dropped.

### CALCULATION FOR INSTANT OF DROPPING LOAD

The calculation of generator field current drop and armature voltage rise the instant load is dropped, is given in "Synchronous Machines—III" by R.E. Doherty and C.A. Nickle, A.I.E.E. TRANS., V. 46, 1927, p. 1-18; and "Two Reaction Theory of Synchronous Machines" by R.H. Park, A.I.E.E. TRANS., V. 48, July 1929, p. 716-30. Extending these derivations to include pole leakage due to saturation, the total per unit field flux linkage under load is

$$\frac{x_{ad}}{-x'_d}\left[I - i_d(x_d - x'_d) + I_s\frac{x'_d - x_{ld}}{x_{ad}}\right] \qquad (9)$$

All quantities are in per unit values and defined as follows:

$x_{ad}$ = armature reaction reactance direct axis
$x_d$ = synchronous reactance direct axis
$x_q$ = synchronous reactance quadrature axis
$x'_d$ = transient reactance direct axis
$x_{ld}$ = armature leakage reactance direct axis
$i_d$ = $i \sin(\delta + \phi)$
$i$ = load current
$\delta$ = load angle
$\phi$ = power factor angle
$I$ = full load excitation neglecting saturation
$I_s$ = excitation due to saturation

During sudden changes of load, the quantity in the bracket of eq. 9 must remain constant. This may be denoted by $\Psi'$ as follows:

$$\Psi' = I - i_d(x_d - x'_d) + I_s\frac{x'_d - x_{ld}}{x_{ad}} \qquad (10)$$

A curve of $\Psi'$ and per unit field current can be plotted from the open circuit saturation curve of the machine. Then for a given load condition $\Psi'$ can be calculated, and when load is lost it remains constant the first instant; hence, from the curve of $\Psi'$ the per unit excitation the first instant can be obtained and the corresponding voltage read from the saturation curve.

The effect of amortisseur winding currents is neglected due to their fast time constant.

### NUMERICAL EXAMPLE

An application of the method described will be illustrated by calculations for a 37,500-kw., 0.8-power-factor generator. Actual tests were made on this machine and provide a check as to the accuracy of the method.

Generator constants:

$X_{ad}$ = 0.76 $X_{ld}$ = 0.27
$X_d$ = 1.03 $T'_{do}$ = 4.5 seconds
$X_q$ = 0.65 $r$ = 0.337 ohms (field circuit resistance)
$X'_d$ = 0.37 Saturation curve, Fig. 4

Main exciter constants:

$r_o$ = 4.32 ohms (shunt field resistance)
$L_o$ = 7 henrys (inductance of shunt field circuit)
Saturation curve, Fig. 3.

Pilot exciter:

Saturation curve, Fig. 2.
Bridge type rheostat constants:
$r_1$ = 4 $r_1'$ = 100 $r_2$ = 48 (refer Fig. 1)

By using the saturation curve of Fig. 2 for various speeds and the speed-time curve of Fig. 6, the pilot exciter voltage curve Fig. 5 is plotted. Eq. 1 then becomes

$$e_1 = 250 + \frac{210}{2p + 1}1$$

With the constants given for the rheostat and main exciter, eq. 5 becomes

$$i_o = -2.3 + 1.16\,\epsilon^{-0.5t} + 19.35\,\epsilon^{-10t}$$

The curve of $i_o$ is plotted as shown on Fig. 5. By using this, the speed-time curve of Fig. 6, and the saturation curve of Fig. 3, a curve of slipring (main exciter armature) voltage as a function of time is plotted as shown in Fig. 5. The operational equation, eq. 6, becomes

$$E = 265 + \frac{295}{0.165\,p + 1}\,1$$

Hence, eq. 8 becomes

$$I = 785 - I_o'\,\epsilon^{-t/4.5} - 1180\,(0.75 - 0.78\,\epsilon^{-0.22t} + 0.03\,\epsilon^{-6t})$$

It will now be shown how to calculate the value of $I_o'$. For the particular machine under consideration, eq. 10 becomes

$$\Psi' = I - i_d\,0.66 + 0.132\,I_s$$

The machine was delivering 40,000 kw. at 0.9 power factor and normal voltage, or 44,500 kva. when load was dropped. Hence, based on machine rating 0.94 per unit current was flowing.

For this condition

$$\delta + \phi = \tan^{-1}\frac{ix_q \sin = \phi}{\cos\phi}$$

$$\delta + \phi = 49 \text{ deg.}$$

Hence

$$i_d = 0.94 \sin 49 \text{ deg.}$$
$$= 0.71$$

$I$ is excitation neglecting saturation and is obtained as follows: Referring to Fig. 7

$$e_d = I = e_t \cos\theta + j\,(e_t \sin\theta + i_a x_d)$$
$$= 0.9 + j\,(0.435 + 0.97)$$
$$= 1.67$$

where

$e_d$ = per unit voltage back of synchronous reactance
$I$ = per unit field current to produce $e_d$
$e_t$ = per unit terminal voltage
$i_a$ = per unit armature current
$\theta$ = power factor angle

$I_s$ is excitation due to saturation and is obtained as follows. Referring again to Fig. 7

$$e_v = I' = e_t \cos\theta + j\,(e_t \sin\theta + i_a x_{ld})$$
$$= 0.9 + j\,(0.435 + 0.254)$$
$$= 1.13$$

where

$e_v$ = per unit voltage back of leakage reactance
$I'$ = per unit field current to produce $e_v$

Thus 1.13 is the per unit excitation necessary neglecting saturation; but from the saturation curve we find it takes 1.38 per unit excitation to get 1.13 per unit voltage, hence, $I_s = 0.25$ due to saturation. Therefore; the value of $\Psi$ becomes

$$\Psi = 1.67 + 0.71\,(0.66) + 0.132\,(0.25)$$
$$= 1.24$$

When the machine loses load, $i_d$ goes to zero and the first instant $\Psi'$ must remain constant. So we turn to the no-load curve of $\Psi'$ and find that the value of field current necessary to produce 1.24 $\Psi'$ is 1.58. Also, from the no-load saturation curve we find that 1.58 field current produces 1.18 voltage, the value obtained at $t = 0$.

On this particular machine, unit field current is 420 amperes (air-gap line, normal voltage). Hence, the value of field current the first instant is 663 amperes and $I_o'$ is 122 amperes.

Using this value of $I_o'$ and dividing through by 420 to change to per unit, we get for generator field current

$$I = (1.87 - 0.29\,\epsilon^{-0.22t}) - 2.8(0.75 - 0.78\,\epsilon^{-0.22t}) + 0.03\,\epsilon^{-6t})$$

Plotting this equation results in the current curve of Fig. 6 and using this with the open-circuit saturation curve of the generator and its speed-time curve, the generator terminal voltage is plotted as in Fig. 6. The results check with surprising accuracy, values obtained by test considering that there were four or five cycles of arcing in the breaker disconnecting the load and that calculated values of unsaturated machine constants were used.

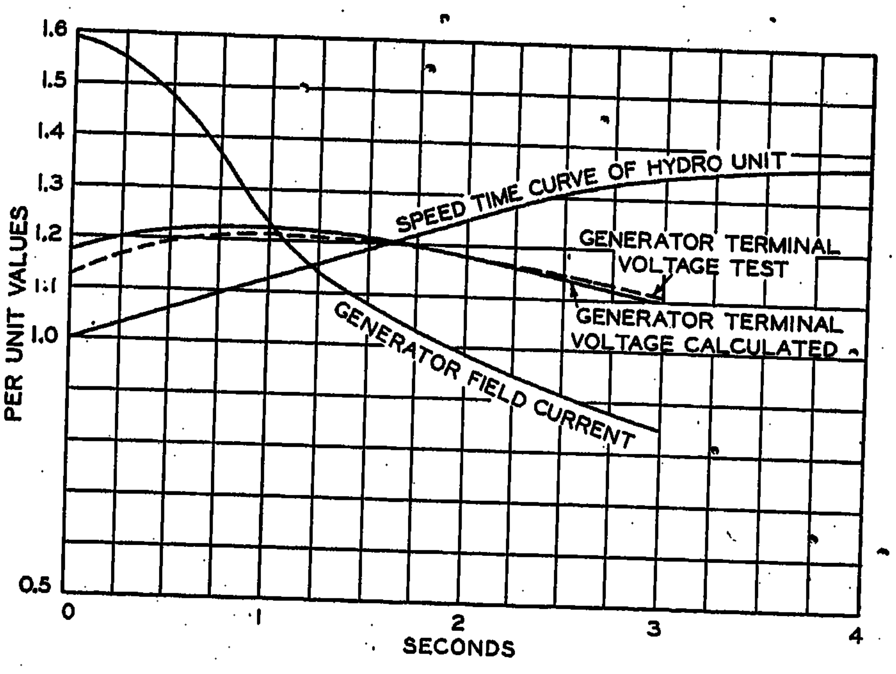

Fig. 6. (Above) Generator and hydro unit characteristics

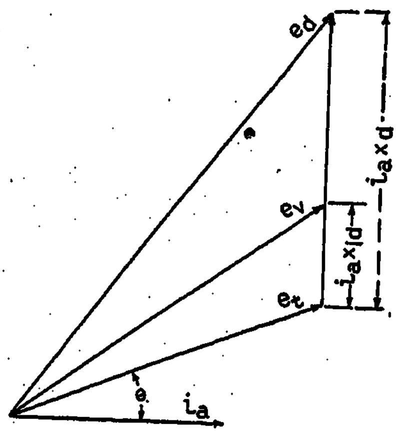

Fig. 7. (Right) Simple vector diagram of a synchronous machine

# Tape Armored Telephone Toll Cable

Toll cables buried directly in the earth are coming into increased use. Such cables are not installed in the usual clay conduit but are protected by layers of paper, jute, and steel tapes. Complete equipment for laying this cable has been developed.

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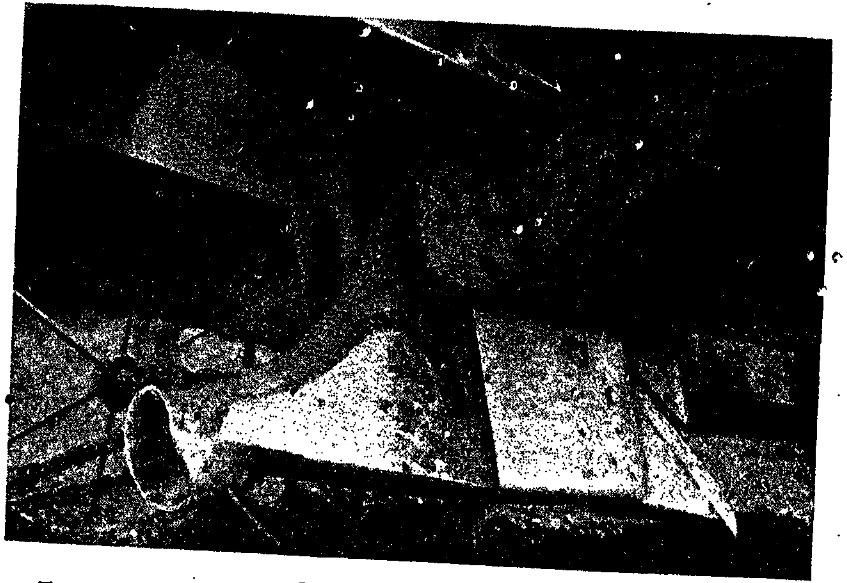

Fig. 1. Lower part of cable-laying plow and tube

TOLL CABLE in this country has in the past been installed either aerially on pole lines, or underground in clay conduit, depending largely upon the number of cable units needed to meet service requirements over a given period of time. Although there will continue to be definite fields for these two types of construction, there are many routes where ground conditions are favorable and on which one or two cables will serve all needs for a long period; it is for these cases that buried tape armored cables were developed.

The cable is termed "tape armored" because of its outer protection. Lead-sheath cable of the type ordinarily used for toll service is covered first with a wrapping of paper followed by two layers of jute roving. Two steel tapes, one over the other, then are applied, each tape being 2 inches wide and 41 mils thick. A separation of one-half inch is maintained between adjacent turns of the tape, and the outer layer is so placed that it covers the space left between the windings of the inner layer. Two wrappings of jute cover the tape. The lead sheath, paper, jute, and steel tapes are thoroughly coated with an asphalt compound; to prevent adjacent layers from sticking together on the cable reels the completed cable is given a coat of whitewash. Such a cable of so-called full size has a diameter of 3¼ in. and a weight of 11.3 lb. per ft. as compared with 2⅝-in. diameter and 8-lb. weight of unarmored cable.

Buried tape armored cables possess several advantages over cables carried on pole line or in underground conduit:

1. Easements for buried tape armored cable on private rights-of-way may sometimes be obtained more cheaply than for pole lines, as the use of the land for ordinary agricultural activities is not disturbed.

2. Induced currents from paralleling power lines are appreciably less than in unarmored aerial or underground cables, due to the shielding effect of the steel tapes. This factor is discussed in "Trends in Telephone and Power Practise as Affecting Coordination," by W. H. Harrison and A. E. Silver, A.I.E.E. TRANSACTIONS, June 1931, p. 437-447.

3. Cable may be laid to follow the contour of rough country and have sharp bends to avoid obstructions, while conduit must have a fairly even grade and long radius curves to permit cable being pulled through it.

4. Manholes are required at spacings of from 500 to 700 ft. if conduit is provided, while with tape armored cables, manholes may be omitted except at loading points which normally occur at 6,000-ft. intervals.

On the other hand, as tape armored cables are buried directly in the earth, the location and repair of troubles are generally more difficult and expensive than for aerial cables. However, improvements in methods for maintaining buried cables should reduce such costs, and in any event, the amount of trouble per cable mile reasonably may be expected to be much less than on aerial cables because of their security from fire, storm, and bullets.

The question of the best possible location for buried cable is one requiring careful consideration. It is thought that right-of-way on private property generally is more desirable than on public highways where road improvements are liable to necessitate expensive cable relocation. On the other hand, the difficulty of obtaining private property easements at a reasonable price, or high construction costs on privately owned land, may make it advisable to place the cable on the highway and so locate it as to subject it to the least probability of having to be moved.

Although with fairly open country, frequent roads, and adequate maps, ordinarily there would be no necessity for a preliminary aerial survey, the first tape armored toll cable in this country was installed by the Southwestern Bell Telephone Company between Fort Worth and Cisco, Texas, in country which made it advisable to photograph the general route from an airplane. The topography for 85 miles of the total 100 miles on this route is extremely rugged, with large quantities of rock in the soil and the ground covered with dense growths of scrub oak and other underbrush. Roads are few and accurate maps were not obtainable. However, the aerial photographs enabled the tentative route to be marked out easily and was of assistance in

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Based upon "Tape Armored Telephone Toll Cable" (No. 31-134) presented at the A.I.E.E. South West District meeting, Kansas City, Mo., October 22-24, 1931.

expediting the ground survey which is of course necessary in any event.

As the Fort Worth-Cisco and other tape armored cables later installed are largely on private rights-of-way, in many instances in cultivated fields, special tractors of the caterpillar type had to be designed to transport the 5-ton cable reels over soft and often muddy ground. There have been also some developments of four-wheel-drive truck equipment for handling deliveries on the right-of-way as well as on the highway.

The equipment for digging the trench, laying the cable, and making the backfill has changed considerably since the early design. For trenching in earth, a commercial wheel type excavating machine was first used and proved quite satisfactory until soil containing a considerable quantity of rock was encountered. A rock-breaking plow then was designed, and answered the needs quite satisfactorily except in cases where solid rock was encountered and pneumatic drills and blasting were required. The cable was laid in the trench directly from the reel, except in such cases as crossing under paved highways and pipe lines, or on steep slopes, where the cable was pulled over rollers placed on the bottom of the trench. Backfilling was accomplished by a separate machine of the type commonly used for filling trenches by scraping the upturned dirt back into the trench.

The use of the rock-breaking plow focused attention on the further possibility of combining the equipment. This led to the development of the outfit shown in Fig. 2 which not only digs the trench but also lays the cable and then fills the excavation, all in one operation. The equipment consists essentially of two main parts, a chassis, and a vertical central portion which may be raised or lowered to bury the cable at depths up to 28 inches. Properly speaking the plow of this equipment does not dig a trench, but merely cuts a slot into the ground. Some earth is thrown out and after the cable is laid this is drawn to the center of the slot by the backfiller. If desired, a tractor may be run over the disturbed earth to pack it down.

Two tractors, sometimes three, are required to pull the cable-reel trailer, plow, and backfiller. The essential features of the plow and cable-laying tube are shown in Fig. 1. The forward or cutting end is a steel plate having a sharpened edge and a shoe provided at the bottom to make a larger space for the cable. Side plates are welded to the cutting blade and to the outer sides of the tube through which the cable passes. The cable enters this tube directly from the reel, and as the pipe extends into the ground, the cable is deposited at the bottom of the trench and is not dragged through the ground at any time. After laying more than 300 miles of cable, this plow is still in good condition.

Small boulders and tree roots often made progress very difficult for the cable-laying plow and it was found that with a narrow slot first cut into the earth, the usual plowing and cable laying operations were considerably expedited. The plow used for this purpose is called a rooter plow as shown in Fig. 3. It is of rugged design and fits the same chassis as the cable-laying plow so that either attachment may be used interchangeably.

The lead sleeve covering the cable splice necessary every 750 ft. was at first protected by a cast iron case. This covering was found to be rather expensive and it was felt that a cheaper protection consisting of a wood case made of 2-in. creosoted yellow pine lumber would serve equally well. Space for branch cables is provided by two openings in one of the end pieces. The exposed lead sheath and sleeve within the case are painted with an asphaltum compound and covered with three layers of muslin tape which also is painted with the compound. The loading manholes for tape armored cables also are of 2-in. creosoted yellow pine. After the top is placed, it is covered with earth, the depth from the surface to the top of the manhole being at least 18 inches. This is necessary as it is desirable not to interfere with the use of the land for ordinary agricultural purposes. The type of manhole illustrated in Fig. 4 costs less than one-third that of the most economically built concrete manhole of similar dimensions. Markers

ig. 2. Complete cable-laying quipment of improved design, consisting of tractors, chassis for cable eel, cable-laying plow and tube, nd backfiller

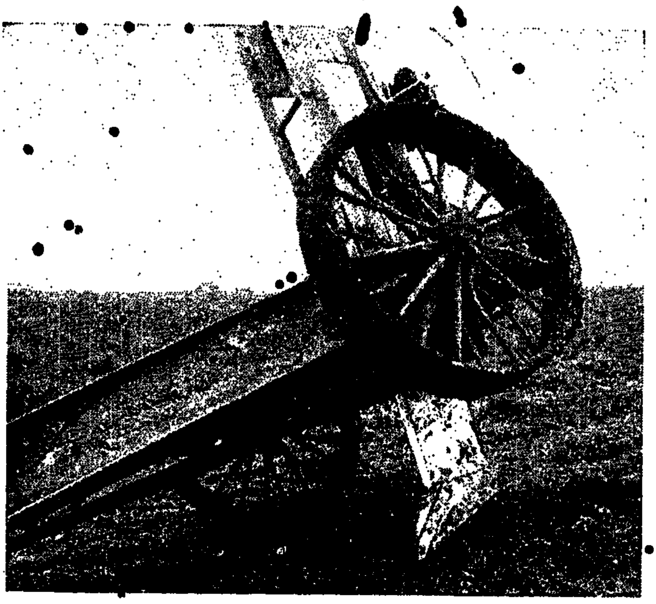
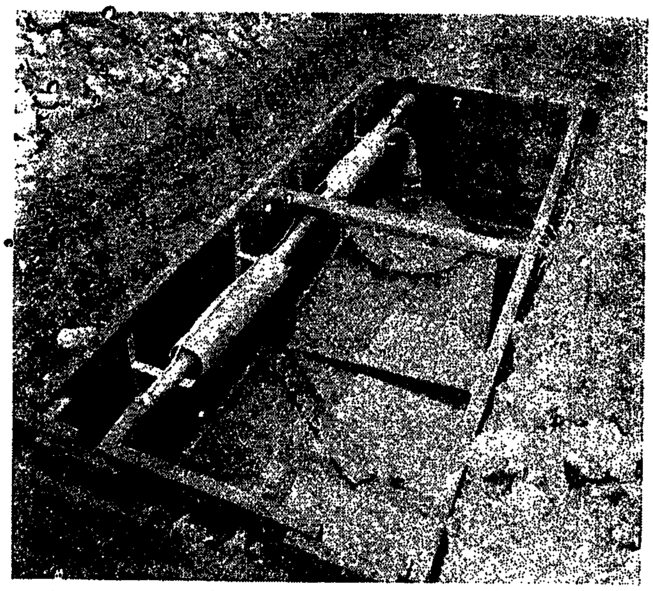


Fig. 3. (Left) Rooter plow which may be placed in the chassis, for cutting a preliminary slot in difficult ground containing tree roots and small boulders

Fig. 4. (Right) Wood manhole. No floor is provided, the loading coil pots being buried in the earth



usually are provided at each manhole and at points along the cable route to enable the ready location of trouble, and the placing of additional loading coils or a future cable. To prevent damage by other excavating activities, warning signs are placed on each side of a road under which cable is laid, at pipe lines and railroad crossings, and at similar locations.

Electrical tests on tape armored cables do not differ appreciably from those used for unarmored cables. It is estimated that the minimum number of tests normally required is 5,150 individual measurements per mile of cable, and if conditions difficult of correction are encountered, many of the tests must be repeated. For the cables between St. Louis and Dallas, the estimated minimum number of individual test measurements reaches the rather astounding total of 4,500,000.

Since troubles in buried cables may be more difficult to locate and clear than for those on pole lines or in clay conduits, it is desirable that tape armored cable, when first placed, be as free as possible from defects which are likely to allow moisture to enter. The lead sheath is tested with nitrogen under pressure, at the factory, upon arrival at the destination, just before the cable is laid or plowed in, one or two days later, and then, before the splicing operations begin. As splicing necessitates the removal of the sheath at each end of a length of cable, most of the gas is lost. Nitrogen again is introduced upon completion of splicing in one loading section, 6,000 ft., and is allowed to remain for about two days. If no leaks are found, the loading coils are spliced in, and the loading splices tested with gas. Gage readings are taken and recorded during all these tests.

A discussion of the application of gas pressure testing for the detection of sheath breaks during installation and with the cable in service has been given by B. S. Wagner and A. C. Burroway in "Recent Developments in Telephone Construction Practises," A.I.E.E. TRANSACTIONS, July 1929, p. 836-848. In connection with constant gas-pressure testing on completed cables, however, two recent improvements seem worthy of mention here. First, the combined contactor-terminal which is compact, gas-tight, may be mounted either in a manhole or on a post, and is so constructed that the contactor may be replaced very easily. The second is an improved alarm circuit that avoids a difficulty possible in the earlier circuits; namely, the operation of any one contactor will render the alarm circuit insensitive to the subsequent operation of any other contactor in the 50-mile cable section until the first contactor is disconnected or the gas pressure is raised in the cable section it covers. This difficulty, resulting from the fact that a single alarm circuit is used for an entire repeater section of cable, is avoided by the plan shown in Fig. 5, based on the wheatstone bridge principle. Contactors at various points of the cable pair operate on reduced gas pressure and they short circuit given values of resistance. Equal values of resistance are located in the bridge at the repeater station. As each pair of resistances has a different value, the attendant at the repeater station merely inserts a non-metallic plug in each jack in turn until the correct one is found as evidenced by silencing of the alarm. The bridge then is rebalanced and remains so until another contactor operates.

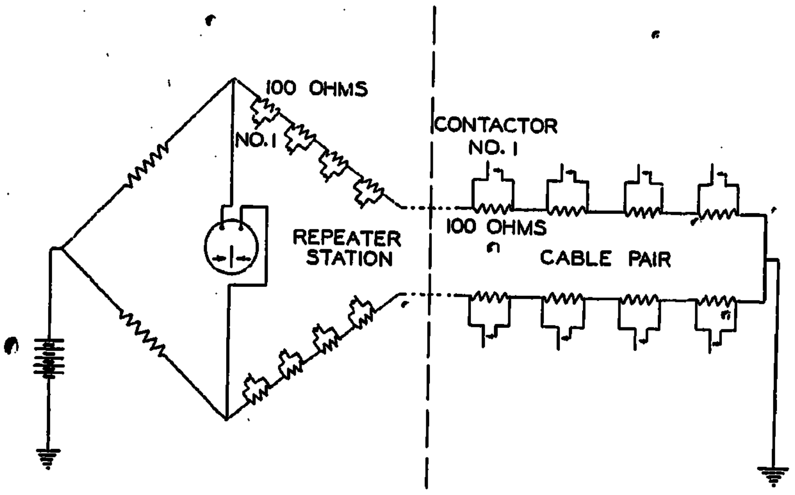


Fig. 5. Circuit of improved gas pressure alarm

To protect the cables during periods when the gas alarm is inoperative, as, for example, when a large sheath break or repair operation may permit practically all the gas to escape from a plug section, another maintenance device known as the low insulation resistance alarm is often used. This operates when moisture entering the cable lowers the insulation resistance between the conductors and the cable sheath. A number of pairs in the outer layer adjacent to the lead sheath is connected to a relay mechanism in the repeater station which automatically and in regular sequence switches these conductors to a sensitive insulation measuring device. A decrease in the resistance below a predetermined value causes an alarm to operate, and wheatstone bridge measurements then are made to locate the trouble The exceedingly small currents flowing through the moistened insulation are amplified by vacuum tubes sufficiently to operate the alarm.

No direct comparisons are available on which to base the relative costs of aerial and buried tape armored cables. However, it appears that one aerial cable on a pole line costs about 90 per cent of that of one buried tape armored cable, and two aerial cables on a pole line would cost about 85 per cent that of two buried tape armored cables. However, certain developments now under consideration promise a rather substantial reduction in the cost of buried cable and if these prove successful, it is quite probable that buried plant may cost even less than aerial cable.

There is another factor difficult of evaluation and that is the effect of service interruptions. Continuous and dependable service is one of the principal objectives of a telephone company and service failures are not only annoying to patrons but result in loss of revenue to the company. As previously discussed, it would seem that buried cable should be subject to less damage from external sources than aerial construction. If this is borne out by further experience, the use of buried cable may become more extensive.

# Paralleling Rotor and Stator

**A wound rotor induction machine may be given special characteristics by connecting the stator and rotor windings in parallel, either directly or through an auto-transformer. Pull-out torque, hp. output, and efficiency at large loads are increased for motor operation; and maximum kva. output is increased for operation as an induction generator.**

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WOUND ROTOR induction motors normally are operated with the sliprings short-circuited. However, both rotor and stator may be independently magnetized thus permitting power to be taken or delivered through any one or two of the three channels, namely, the stator, rotor, and shaft. Further, the stator and rotor voltage and frequency can be adjusted to the same values, making it possible to parallel the stator and rotor. The advantages which have been found for such a scheme are as follows:

1. The breakdown torque of the machine operating as a motor can be approximately doubled, increasing the rating of a given motor.
2. Generator capacity and maximum output can be increased.
3. Higher efficiencies may be secured at large loads.

## STARTING AND OPERATION

The principle of operation of the motor is indicated in Fig. 1. With the switch $S_1$ open, the stator is supplied from the three-phase line, and the rotor is connected to the armature of a synchronous generator. The latter serves as a path for the secondary current, allowing the induction motor to be started and operate much the same as if the rings were short-circuited. If the stator phase rotation is 1-2-3, the voltages induced in the rotor will be of low frequency with a phase rotation of *a-b-c*, causing current to flow in the synchronous machine armature in the order *A-B-C*. The induction motor will rotate in a clockwise direction.

With the stator disconnected from the supply and short-circuited directly or through transformers, and power supplied to the rotor from the alternator, the induction machine may be started again. If the phase rotation of

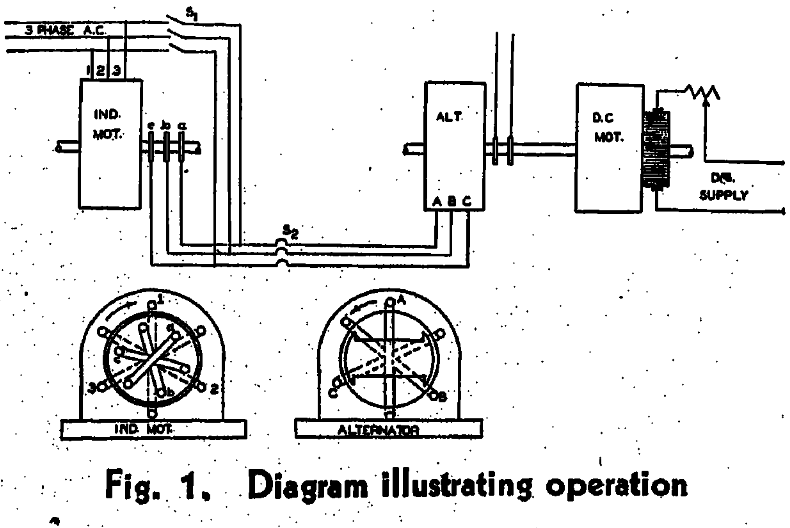

Fig. 1. Diagram illustrating operation

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Based upon "An Induction Motor with Paralleled Rotor and Stator" (No. 32-27) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25-29, 1932.

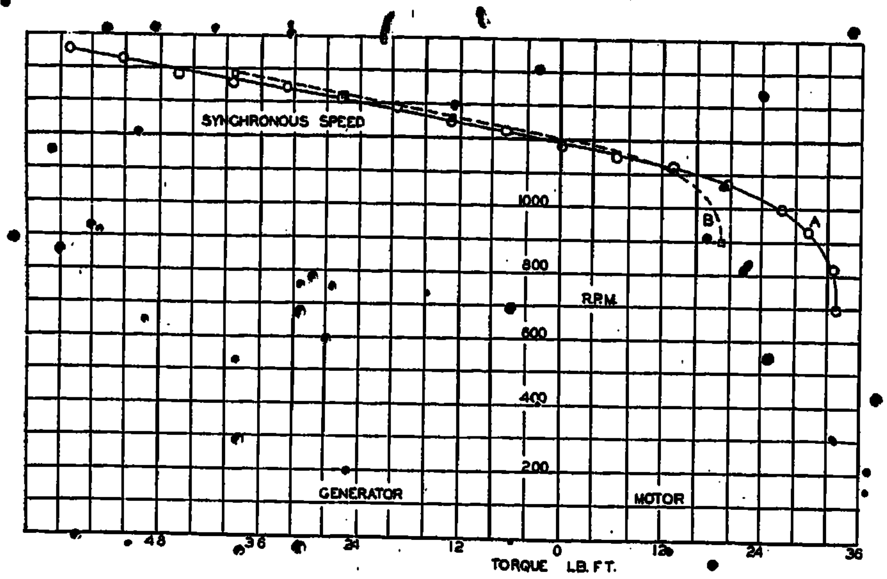
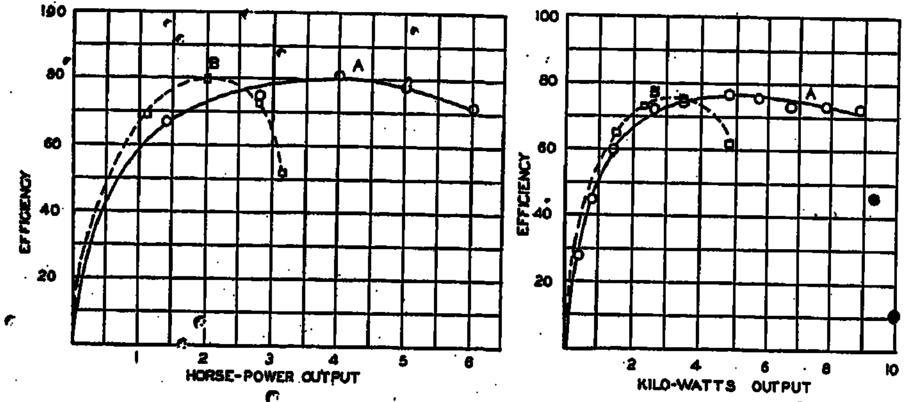


Fig. 2. Speed-torque curves of machine

Curve A—Rotor and stator paralleled
Curve B—Rotor short-circuited



Figs. 3 and 4. Efficiency as a motor (left), and as a generator (right)

Curve A—Rotor and stator paralleled
Curve B—Rotor short-circuited

the alternator is *C-B-A* the induction machine will rotate in the same direction as above, and the low-frequency currents in the stator will be in the direction 3-2-1.

If the stator now is connected to the line in the usual manner, and at the same time the rotor continues to be supplied from the alternator with phase rotation *C-B-A*, the supply transformers will act as a low impedance path for the slip-frequency currents in the stator and the alternator will complete the path for the slip-frequency currents of the rotor. The magnitude of the voltage impressed on the rotor is dependent upon the field excitation of the synchronous machine. The frequency of the voltage depends upon the speed of the synchronous machine. By adjusting these two factors, the rotor and stator can be made to have the same voltage and frequency so that they can be synchronized and electrically connected through switch $S_1$. Switch $S_2$ now can be opened and the induction motor will continue to operate, both stator and rotor receiving power from the line. Rotation will be less than synchronous speed; the high frequency current in the stator will be in the order 1-2-3, and the low frequency currents in the order of 3-2-1. The high frequency currents in the rotor will be in the order of *c-b-a* and the low frequency current in the order of *a-b-c*. The machine when so connected has characteristics similar to those of the normal induction motor. When loaded the speed decreases slightly. When driven above synchronous speed the machine acts as an induction generator; the low-frequency currents in the stator and rotor are opposite in phase rotation to what they are as a motor.

The characteristics of the motor with its rotor and stator paralleled can be determined by applying ordinary induction motor theory. Using slip as parameter it is possible to determine the torque, stator copper loss, rotor loss, etc., by the power fed into the stator and for the same slip determine values for the same items which are produced by the power fed into the rotor.

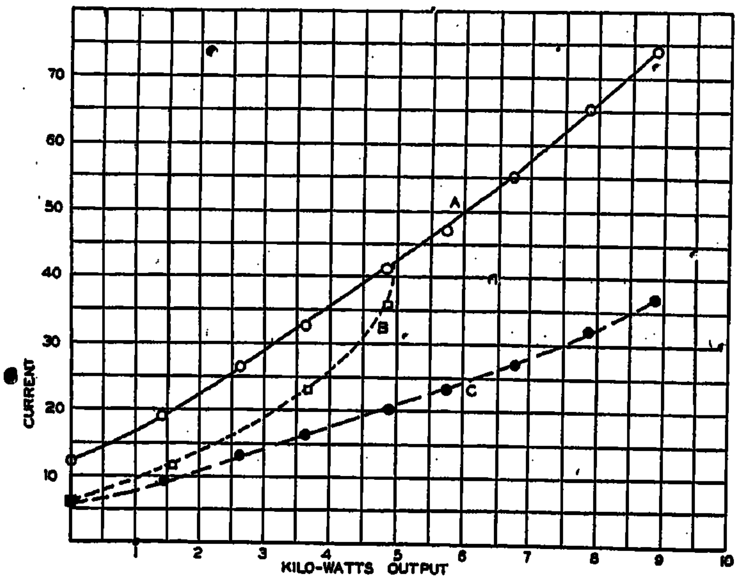


Fig. 5. Currents during generator operation

Curve A—Line current with rotor and stator paralleled
Curve B—Stator phase current with rotor short-circuited
Curve C—Stator phase current with rotor and stator paralleled

## EXPERIMENTAL INVESTIGATIONS

Calculations and analysis of operation were checked experimentally. The machine selected for tests was a wound-rotor induction motor rated 10 hp., 60 cycles, three-phase, 1,140 r.p.m., 220-volt stator, 206-volt rotor. The motor had nearly a 1 to 1 ratio of stator to rotor turns. In order to keep within the limitations of the laboratory circuits, the voltage on each phase was dropped to 110 volts, 60 cycles, and the characteristics were determined with stator and rotor paralleled. In this machine the voltage supplied to each phase is a fundamental voltage, while the current will contain not only a fundamental component but also a low-frequency component. The results of these tests are shown as curve *A* in Figs. 2 to 5. For comparison, curve *B* in each figure shows the characteristics of the motor with normal connections.

As indicated in these figures, the breakdown torque of the motor can be approximately doubled by using the stator and rotor in parallel; likewise that the generator capacity and maximum output can be increased by the parallel connection. With the parallel connection, high efficiencies are obtained for large loads on account of reduced copper losses per unit output. However, the efficiencies are low for light loads because of larger iron losses and copper losses produced by the additional exciting current, the maximum efficiency for the two cases can be seen to be approximately the same for either the condition of motor or generator operation. The curves of Fig. 5 for generator operation show that the phase current with the parallel connection will be less than the phase current with the rotor short-circuited.

The circle diagram of the motor when the rings are short-circuited is indicated in Fig. 6. The no-load losses for this machine are very small but it can be seen that when the rotor and stator are paralleled the no-load line current contains a larger power component. This is because of the increased iron losses due to the high-frequency rotor flux and also the superposition of the two fluxes traveling in the iron at different speeds. In addition to this the exciting current in the rotor causes copper losses which increase the no-load input.

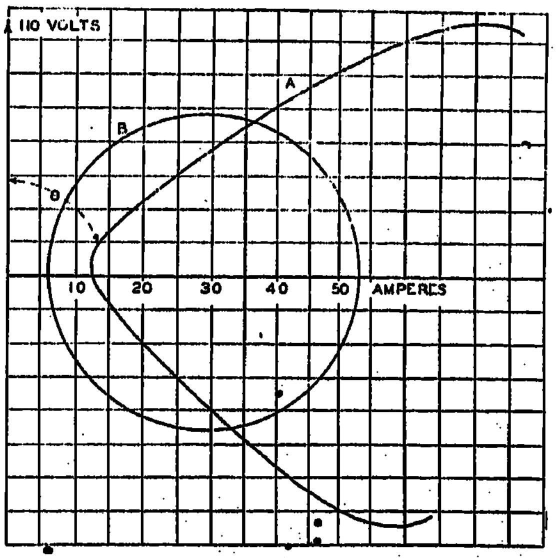


**Fig. 6. Locus of line current**

Curve A—Rotor and stator paralleled
Curve B—Rotor short-circuited

It will be noted also that the maximum power component of the input current is a little less than twice the maximum power component of the motor when its rings are short-circuited. This is caused by a slight terminal voltage drop with these heavy loads. It may be assumed that the heart-shaped diagram would have had a slightly higher maximum power component if the voltage had remained constant. The arithmetic sum of stator and rotor currents was almost equal to the line current.

The exciting current taken by the motor is indicated by the oscillogram of Fig. 7. It can be seen in Fig. 8 that some of the high frequency waves have pointed peaks and the other maximum values of the same wave have rounded points. This indicates a high saturation during part of the cycle.

When the machine is loaded, the high frequency currents and the low frequency currents are each slightly out of phase. This is caused by different constants in the rotor from those in the stator; *i. e.*, the ratio of stator inductance to stator resistance is different than the ratio of rotor inductance to rotor resistance. It also can be seen in Fig. 8 that the low frequency current is slightly less than the high frequency current in the same phase.

The effect of the low frequency currents upon the line will depend to a certain extent upon the ratio of the motor rating to the rating of the transformers supplying the load. It is obvious that if this ratio is large, the efficiency might be reduced.

It is possible to operate a wound rotor induction motor with its rotor and stator paralleled when the voltage ratio is not 1 to 1, by connecting the low voltage rotor to the high voltage line through an autotransformer. The behavior of the machine under these conditions should be better than when no transformer is used, since the transformer will by-pass part of the low frequency current that ordinarily would flow through the supply transformers

The tests made on the machine as a motor and as a generator indicated two disadvantages of the parallel connection; the machine was noisy and the exciting current was high. This noise might be eliminated by special designing. Also due to the superimposed fluxes rotating in opposite directions the iron of the motor was saturated; this difficulty could be minimized by a special design.

Variations in the rotor and stator constants and in external resistances permit a number of combinations of motor characteristics to be obtained, including both high starting torque and good regulation. Also if the machine is to be subjected to a wide range of load, maximum efficiency may be obtained by the use of a switching arrangement in the rotor that will short-circuit the rings when the load is light, and connect the rotor and stator in parallel when the load is heavy.

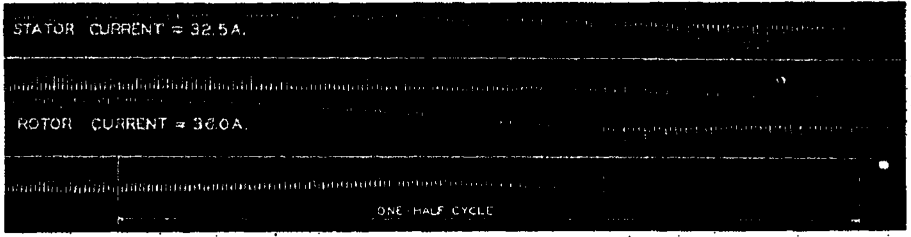


**Fig. 7. No-load currents with rotor and stator paralleled 245 volts applied**

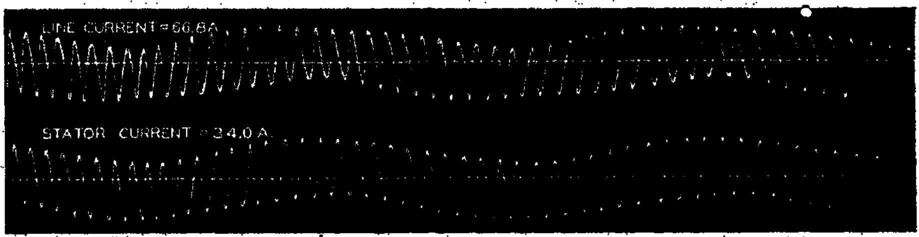


**Fig. 8. Full-load current with rotor and stator paralleled 220 volts applied**

# Interconnection of Electric Power Systems

**Companies with adjacent power systems are showing an ever increasing tendency to interconnect their properties. Supplementing previously published information, the following four articles classify and discuss the various interconnection services available.**

INTERCONNECTION refers to the physical tying together of two or more independently owned or managed electric systems for the purpose of realizing financial benefits or improvement of service by the interchange of power and energy. The importance of linking power sources, transmission facilities, and load areas is fully recognized. Interconnection aids the electric utility industry in providing the customer with an electric supply adequate to his requirements in quantity, quality, and reliability.

In order to take full advantage of an interconnection, careful studies must be made, based upon a thorough understanding of the problems of each of the systems. The various factors involved first should be classified and defined so as to avoid confusion and error in comparing different schemes.

The subject of interconnection may be considered under the arbitrary divisions of (1) classification of service; (2) evaluation or economics; (3) contract; (4) design and construction; and (5) operation. The first two divisions, namely classification and evaluation, are considered by A. E. Bauhan in the first of the four articles immediately following. The second article, that by G. M. Keenan, discusses the development and operation of interconnected power systems, placing emphasis on the execution of a well formulated operating plan. The third article, by E. W. Dillard and W. R. Bell, enumerates the advantages as well as some of the disadvantages and difficulties in operating a particular interconnected system covering the more densely populated sections of New England. The last of the group, an article by H. S. Fitch, describes the plan of interconnection and operation of contiguous power systems independently serving a vast industrial region of Pennsylvania, Ohio, and West Virginia. In this case each system is under separate control, both financial and operating, with all the diverse standards and ideas of technical, commercial, and accounting nature.

## Interconnection Services Classified and Evaluated

By
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DETERMINATION of the economic merits of an interconnection, that is, its evaluation, is greatly facilitated by an orderly and logical classification of the services which that interconnection will render. Recognition of the various classes of service is not only helpful but is quite essential in the preparation and application of the interconnection contract, as each class of service requires different provisions and rates of payment. Such classification is helpful in rationalizing design, as for instance in determining whether the services to be rendered by the interconnection warrant a double or only a single circuit.

The classification offered here is not intended to be an enumeration of benefits rendered by interconnection but rather a delineation of the types of transactions which take place over interconnections. It is an attempt at earmarking or labeling the various amounts of power or blocks of energy in the light of what they do—of what service they perform—as necessitated principally by evaluation and contractual expression. Seven main service divisions may be recognized: emergency service, load diversity, firm power, storage power, intra-company use, economy flow, and unintentional flow.

Emergency service is the assistance which one company renders to another in the event of breakdown of equipment, unusual load demands, or other abnormal conditions resulting in power requirements in excess of the capacity of the normal power sources of the company in difficulty. When emergency service makes possible a definite recognizable reduction in the amount of generating capacity it is sometimes referred to as reserve diversity.

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Based upon "Interconnection Services, Their Classification and Evaluation" (No. 31-106) presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

Load diversity refers to those transactions which result in a saving of generating capacity by reason of the non-coincidence of the times of the peak loads of the interconnected companies. For instance, if a system having a morning peak is interconnected with a system having its peak at 5:00 p.m. a saving in generating capacity results. If the diversity is found to be, say, 40,000 kw., each at the time of its peak could receive from the other 20,000 kw., thus realizing a saving of installed capacity of that amount. Three subdivisions of load diversity, daily, monthly, and yearly, are illustrated in Figs. 1, 2, and 3. The total diversity saving is equal to the daily diversity of the combined-peak day plus the monthly diversity of the combined-peak month plus the yearly diversity.

Firm power arises when one company, instead of installing necessary generating capacity in its own system, chooses to buy power from the other system. It involves a sale contract of either long or short term, with a firm obligation on the part of the seller to hold available capacity for the use of the buyer in lieu of installed capacity.

Storage power transactions involve the conversion of energy generated off-peak in one system into peak capacity in another system, through the medium of storage, usually the storage of hydraulic potential energy. There are two classes of storage power transactions; (1) pumped storage, by which relatively low-cost energy is used to pump water into a storage pond during off-peak hours; and (2) improved utilization of storage, in which generation during off-peak hours is substituted for energy which would otherwise be taken out of storage. In either case the stored energy is utilized at such a rate of discharge and at such a time as will create additional capacity values. Examples of storage power transactions are illustrated in Figs. 4, 5, and 6.

Intra-company use refers to interconnecting facilities used by one of the companies in place of other facilities which otherwise it would have had to provide for its own purposes. Interconnecting facilities which may thus be used include transmission lines and structures, substation equipment, tertiary windings in interconnection transformers which take the place of separate two-winding transformers, and rights-of-way. In some of these transactions energy for intra-company use is commingled with interconnection flows, and in such cases contractual arrangements are necessary to provide for their separation and to limit the intra-company use so that interconnection flow is not unduly hampered.

Economy flow occurs when energy used by one system and which could have been generated by that system is for the sake of economy actually generated by another.

Unintentional flow is included because it is desirable to consider deviations from the intended flow and inadvertent flows when none is intended.

## EVALUATION

Before decision can be reached as to whether or not a proposed interconnection should be installed, it is necessary to estimate and present its economies. The following is intended to indicate the general procedure and mode of attack to be used in evaluating a proposed interconnection.

*Generating Capacity Savings*—From the load data and operating characteristics of the systems it will be determined that certain capacity savings are to be realized by taking advantage of the various services which have been enumerated. For instance the availability of emergency service may make it possible to reduce the spare capacity from 20 per cent or 25 per cent to 15 per cent, or from 15 to 10 per cent; or, where without interconnection it had been thought necessary to have three spare generating units, with interconnection it may be decided that two units will suffice. If there is load diversity in the interconnected systems this results in a comparatively definite capacity saving. Similarly, the opportunity for storage power transactions yields a determinable capacity saving.

*Capital Cost Saving*—After the amount of capacity saved has been ascertained the resultant capital cost saving must be determined by applying appropriate

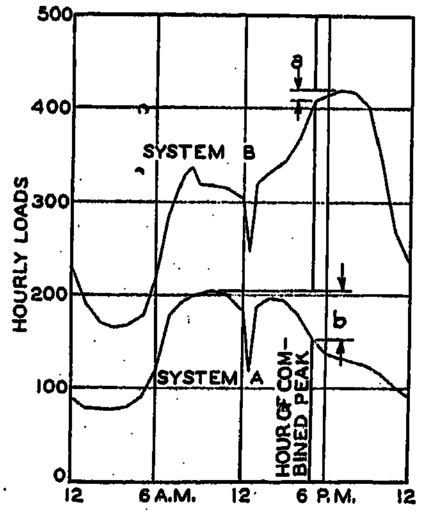

**Fig. 1. Daily load cycle**

Daily diversity = a + b

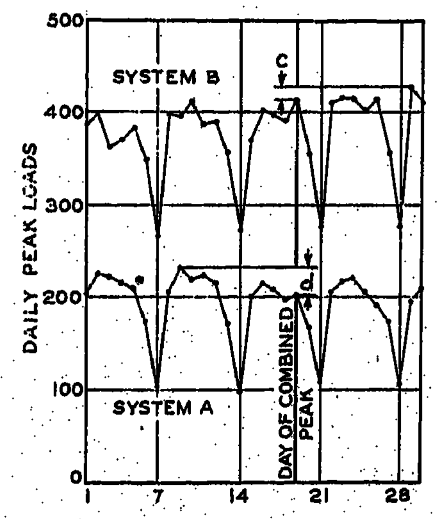

**Fig. 2. Monthly load cycle**

Month diversity = c + d

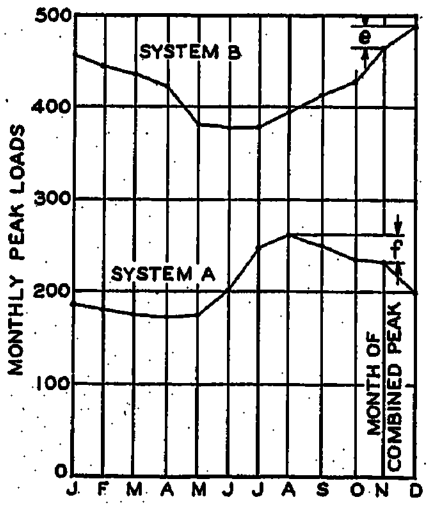

**Fig. 3. Yearly load cycle**

Yearly diversity = e + f

unit costs to the kilowatts of avoided capacity. If a more concrete study is being made, the particular year-by-year program of generating station investments "without interconnection" may be set up and compared with the "with interconnection" program. Any capital savings resulting from intra-company use of the interconnecting facilities or from firm-power transactions must also be taken into account. The total capital cost saving then is compared with the capital cost of the interconnection.

*Annual Fixed Charges*—Avoided investment naturally results in a reduction of generating station fixed charges. On the other hand, fixed charges are incurred on the interconnecting facilities. The term fixed charges ordinarily is meant to include the annual costs in money, insurance, taxes, retirement expense, and general expense; and in the case of facilities other than generating stations, it is sometimes convenient to include operation and maintenance expense. Usually they are determined and expressed as a percentage of capital cost.

The annual cost of money represents the compensation which must be given to capital to attract it to industry for the purposes under consideration. In the absence of abnormal conditions it is likely to be the prevailing allowable return on public utility property. Insurance, it should be remembered, includes not only premiums paid for all types of protection but also the cost of any self-insurance. Taxes can be determined only after careful consideration of the manner and the amount in which they are levied in each particular locality. Taxes levied on the gross receipts of the company ordinarily have no effect on interconnection economics. The necessity for including income taxes, with proper recognition of the effect of borrowed funds, must not be overlooked. Retirement expense should be determined on a sinking fund basis using the rate of interest earned on securities suitable for investment in trust funds. General expense includes administrative salaries, general office expenses, law expenses, relief and welfare work, etc. In some cases it may be considered that general expense will be unaffected by interconnection.

Naturally, no generally applicable fixed charge percentages can be cited. However, to indicate the order of the fixed charges it may be said that for steam-electric generating stations they frequently will be about 12 or 13 per cent, and for hydroelectric developments perhaps 9 per cent or 10 per cent. For steel tower transmission lines fixed charges are affected somewhat by the proportion of the investment in right-of-way, but they may be from 12 to 14 per cent with operation and maintenance expenses included. Substations, likewise including operation and maintenance expenses, will be somewhat higher; usually between 14 and 17 per cent.

*Annual Production Expense Savings*—After the saving in fixed charges has been determined it remains to evaluate the effect of interconnection on generating station production expense. This requires, first, determination of station load schedules with and without interconnection and, second, application of the individual station production expense formulas to the end that the changes in the fixed and variable elements of production expense be determined.

The output of each station and the character of its load for most economical conditions with and without interconnection may be obtained by resorting to integrated duration curves, or duration curves, for the loads of the individual systems on one hand and for the combined system on the other, on an annual, seasonal, or monthly basis, according to the degree of precision desired. Due allowance must be made for the outage of generating units for normal and abnormal mainte-

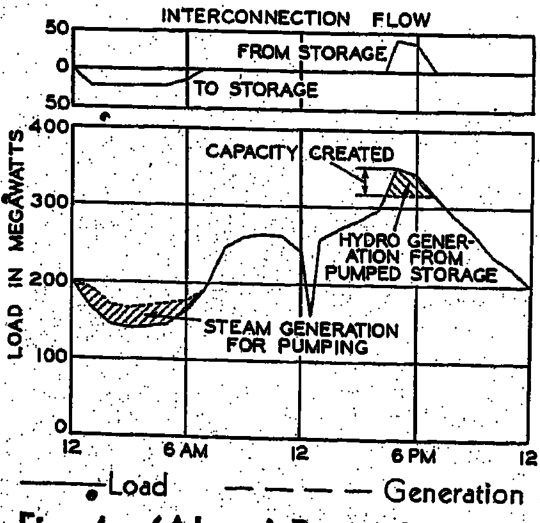

**Fig. 4. (Above) Pumped storage**

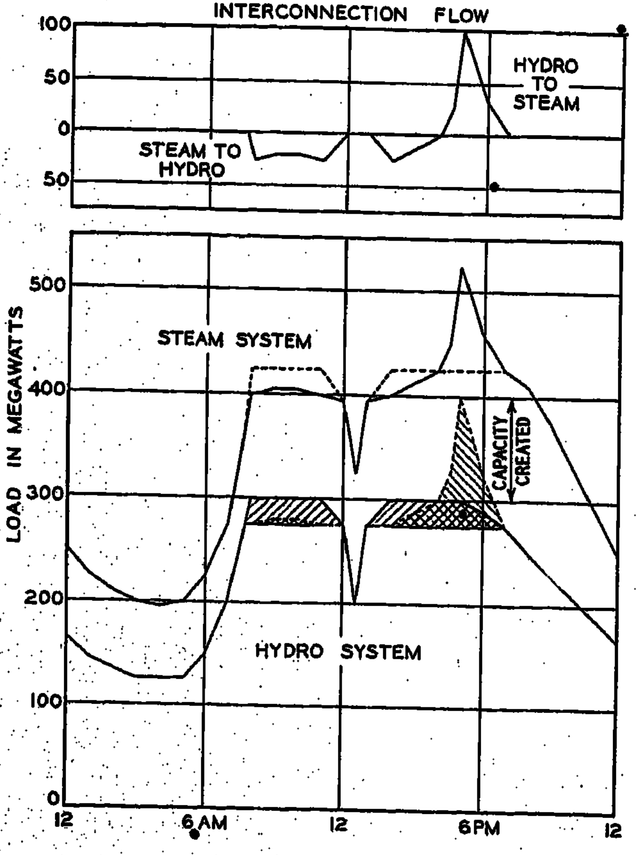

**Fig. 5. (Middle) Improved use of storage on systems having dissimilar peak characteristics**

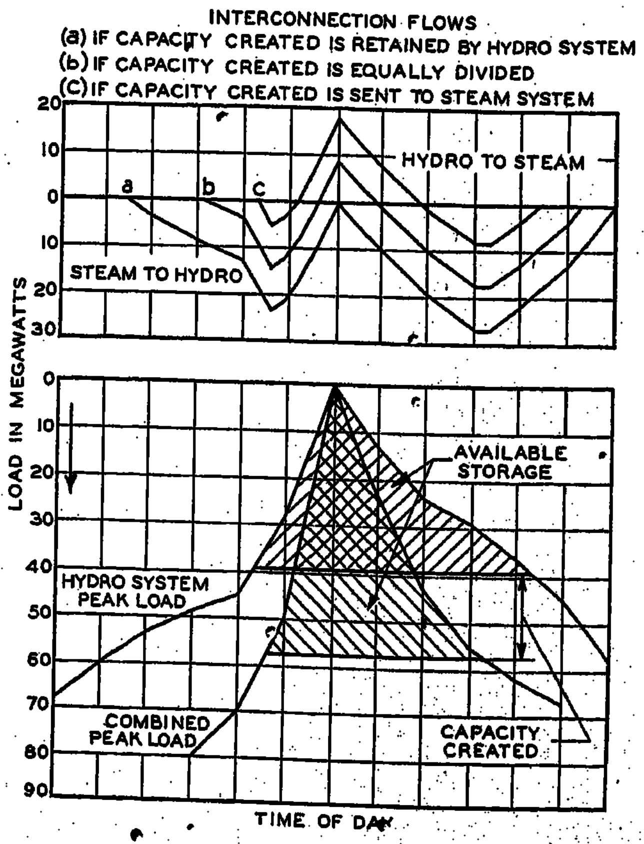

**Fig. 6. (Extreme right) Improved use of storage with similar system peak characteristics**

nance. It must be remembered that the interconnection transactions will be limited by transmission losses, the capacity of interstation and interconnection transmission, the necessities of service protection in local areas, minimum steaming conditions, and the minor imperfections of operation and of contracts.

Before the production expense savings due to interconnection can be determined it is necessary to know the behavior of production expense as a function of station output for each generating station in the interconnected systems. For interconnection studies the two-part annual production expense formula has been found sufficiently accurate and most suitable. Derivation and use of this formula have been discussed in "Presidential Address to Junior Engineering Society" by Dr. John Hopkinson in Transactions of Junior Engineering Society (British) 1892, and reprinted in *Rate Research*, v. 2, 1912, p. 23-38; and in "Discussion of the Elements Entering Into the Cost of Producing Power" by W. B. Skinkle in *Iron and Steel Engineer*, June 1928, p. 278. Such a two-part formula arises from the experience that within a limited range of annual capacity factors the production expense is made up of a fixed element independent of annual output and a variable element directly proportional to the number of kilowatt-hours generated in the period.

Obviously the avoidance of generating capacity installation accomplishes a reduction in the fixed element of production expense. Approximately, and frequently with sufficient accuracy in the case of a long-term study, the saving in fixed element expense is the number of kilowatts of avoided capacity resulting from the interconnection transactions multiplied by a figure (for large steam stations possibly between $3.00 and $5.00) representing the fixed element of production expense per kilowatt of avoided capacity. Its effect is similar to avoided fixed charges.

The change in variable element of production expense involves only the multiplication of the energy quantities determined for each generating station with and without interconnection, by the corresponding increment cost per kilowatt-hour from the two-part formula and obtaining the difference between the two plans of operation. Frequently the net effect of interconnection on this item is not a saving, but a decided loss. The explanation of course is that the interconnection forestalls installation of modern, highly efficient equipment, and increases the duty on older plants having higher variable costs.

*Net Savings*—Net savings resulting from the interconnection are obtained from the combination of net fixed charge savings and net production expense savings, which may well be presented by means of a tabulation showing the amount of these savings for each year studied.

No attempt has been made here to show how savings may be divided between the interconnecting parties, since this is a matter for agreement between them. Nevertheless, it is a factor which may affect some of the items of evaluation, and certainly requires careful recognition of the equities for each particular class of interconnection service in the agreements relating to the project.

# Interconnection Development and Operation

By
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SYNCHRONIZED electric supply systems function as a unit, all the component parts responding to variations in the load demand. Under the interest of single ownership this inherent unit characteristic naturally was recognized but through the screen of diverse interests of multiple ownerships in interconnection is not so clearly apparent. If the best economic results are to be obtained the development and operation of each part must be related to the development and operation of the whole unit.

How much coordination is required? Some believe that all the benefits of interconnection can be obtained only by developing and operating the system just as though it were all owned by one company. The trend in that direction is inevitable and the individual company's interests need not be submerged by such a procedure. Others believe all the practical benefits may be obtained with much less coordination; that continuing interconnection over greater and greater areas so complicates complete coordinating arrangements that they become economically unjustifiable, and that better results will be obtained by maintaining stronger company individuality. It generally is agreed, however, that there must be at least sufficient coordination to care for equities in established contracts and to avoid penalizing any of the participating companies.

## DEVELOPMENT OF INTERCONNECTIONS

Coordination in development of the interconnected system usually requires cooperative planning of generating capacity, interconnected transmission, border line service to customers, and system operating facilities. The intention is to provide the economically right

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electric supply system for the load areas served while so arranging the business relations between the ownerships as to share equitably the benefits between the customers and stockholders of the properties involved.

Generating capacity must be distributed economically among the various types of steam and hydroelectric stations strategically located in relation to the load requirements and properly correlated for the absorption of all available by-product power from irrigation, navigation, flood control, water supply and industrial development. There is no difference between this problem and that of a system under one ownership, except in the breadth of its scope and possibilities.

The interconnecting transmission system should be developed cooperatively to assure the economical utilization of the generating capacity and the reliable supply of electric service to load areas with sufficient operating flexibility in the system design to permit prompt resynchronizing when portions have been separated from the main system. The tendency is to increase transmission costs, and special effort is required to maintain the proper economic balance. Performance of interconnected loops is demanding more and more attention. Short-circuit current, stability, voltage regulation, and power flow in closed loops must be analyzed, and if necessary controlled by special equipment.

Service should be supplied border line customers in the most economical manner regardless of ownership, and the proper equities worked out between companies.

### Planning of Operation

Cooperative planning of system operating facilities is essential as a result of the unit characteristics of the interconnected system. The men directing the operation must be provided with adequate facilities to show what is going on, to determine how the performance should be properly correlated and readjusted, and to take the necessary action to accomplish the results required. The objective in the operation of electric supply systems is to produce most economically the most reliable service possible with the system provided; at the same time, maintenance must be accomplished efficiently. The coordination of all operating and maintenance personnel and operating equipment on the system to bring about this objective requires careful planning and execution.

Interconnected system operation differs from system operation under single ownership only in the method by which the objective is accomplished and in the necessity of properly caring for the equities resulting from differences in ownership. Some interconnected systems have gone to centralized control just as have all corresponding systems under one management. Planning with centralized control requires assembling yearly, monthly, and weekly load and maintenance forecasts for the various systems in the interconnection, and consolidating them into one interconnected system forecast. Operating schedules are prepared, based on these predictions and with a complete knowledge of characteristics and costs of all fuel generating stations, as well as quantity and limitations of available hydroelectric and by-product power.

On interconnected systems where centralized direction has not been established each company carries through its own planning and then checks with adjoining companies. Knowing the costs of the blocks of generation above and below that sufficient to carry its own load, each company determines with its neighbor where load and reserve can be placed for greatest economy.

### Execution of Operating Plan

An interconnected-system operator coordinates the performance of the individual companies in the execution of the operating plan where centralized direction is provided on the interconnection. The various company system operators do not report to the interconnected-system operator any more than a switchboard operator reports to a local system operator. Only such coordinating directions are given and received as are required to produce dependable, economical, unified operation; in neither case is there any need for loss of individual initiative or responsibility. The function of the interconnected-system operator in some cases is assigned by mutual consent of the companies involved to some one company system operator.

The interconnected-system operator keeps in touch with the demands made upon the system and the performance of the personnel and equipment in meeting those demands. His course is charted by the schedule of operation which has been prepared. He compares the demands which have developed with those predicted, and from his thorough knowledge of all elements of the system, adjusts the performance of equipment and personnel to compensate most economically and effectively for deviations of the actual from the scheduled demands.

Details of directing are so numerous that it is essential to develop a method of procedure which delegates as far down the line as possible, the detailed observation of indications and responsibilities for compensating adjustments. Direction is superposed only where coordination between the operating points is necessary. Every switchman, substation operator, and generating station operator usually is allowed to do all he can without coordinating direction from the local system operator of his area who, in turn, handles all he possibly can without coordinating direction from his company system operator. Methods of procedure and standard practise are established through written operating instructions reducing to a minimum the number of directions necessary for either emergency or normal operation. Complete and thorough training of all the operating personnel is essential to be sure that everyone can be counted upon to respond as promptly as possible, and thus harmonize action over large areas even though the individuals do not know just what is being done simultaneously by other individuals.

When such a system is well established with well trained personnel, lightning storms and similar emergencies are handled satisfactorily without any one person knowing all that is taking place; in fact often it becomes necessary to spend some little time on assembled records after the emergency is over in order to determine what actually happened and whether or not individual equipment and personnel have functioned properly.

Most existing interconnections have no centralized direction. The system operators of adjoining companies coördinate the performance of their companies and by such action, progressing through the interconnected group, produce unified operation. In exactly the same manner, many companies have handled their own operation between the switchboard operators at two or three generating stations before justifying system operators. The effectiveness of the de-centralized method is increased by occasional meetings of those directing operation of the individual companies where operating problems and practises may be reviewed and a mutual agreement reached on methods of procedure.

In a closed loop interconnection without phase shifting transformers or other such equipment, it is impossible to direct the power flow. Adjustments can be made only for the individual company's conditions by so regulating that company's generation as to produce the net power flow desired. As yet no satisfactory method of accounting for equities in interconnected loop operation between several companies has been developed.

Little attention is paid to the power flow on tie lines in a system under one ownership until there is danger of reaching some physical limitation on the circuit. Power flow on tie lines between different ownerships in interconnection, however, becomes one of the bases on which money is exchanged; therefore it becomes a part of execution of the operating plan to sort out, classify, and account for the different classes of power flowing. Unless care is exercised in establishing principles not only in operation but in the contracts, this work is likely to become excessively complicated.

As long as the properties are synchronized so-called incidental or uncontrollable power will flow across the interconnection even though no power flow is scheduled. It is necessary therefore to have an incidental rate which will encourage complete utilization of the instantaneous diversity without penalizing anyone.

An encouraging emergency rate is necessary which will induce everyone to rely upon the interconnection reserve but which will at the same time adequately compensate those properties producing the power in emergency. The rate used for a sustained emergency must compensate the property supplying the capacity and yet not penalize too severely the companies using the capacity, unless the necessity for this use has arisen from negligence in maintenance, poor planning, and development or wilful leaning to prevent investment in capacity.

In interconnection as in democratic government the total benefits to be shared are in proportion to the total participation; and the regulation imposed on the individual participant should be the minimum which is necessary to make the benefits proportionally available to all.

# Interconnection in the New England District

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COMPREHENSIVE interconnection of power generating sources has developed in New England largely because of the high load density and the economical combination of hydroelectric and steam-electric sources which have existed in this territory. The first ties were made somewhat prior to 1917 and were used to obtain steam relay power for hydroelectric developments, and to provide a market for surplus energy generated by water power. More recent ties have been made to permit also the absorption of large quantities of surplus steam-electric power from high grade steam plants and to pool resources by the sale of firm capacity in order that economical construction schedules might be obtained.

## BENEFITS DERIVED

Interconnected companies not under a common financial control have not availed themselves of peak diversity to save capacity installation; each company has assumed responsibility for its own primary load. Although 5 per cent diversity amounting to say 50,000 kw. exists, this is utilized as a worthwhile safety factor, and the systems therefore are continually tied together even though kilowatthours are not exchanged. Between certain of the commonly owned groups, a larger di-

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Based upon "Interconnection—New England District" (No. 31-107) presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

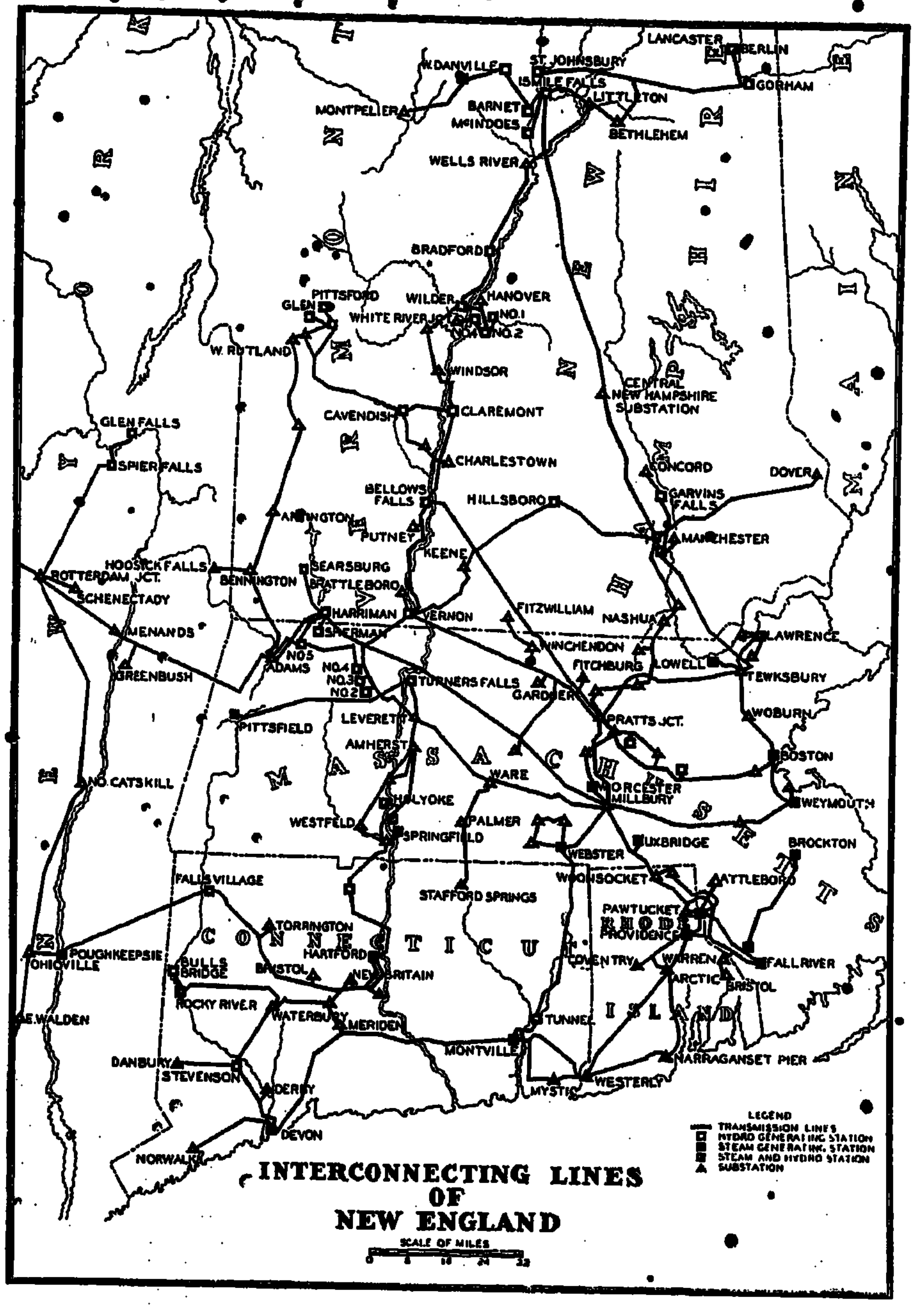

Fig. 7. New England interconnection

versity on the order of 7 per cent is utilized at a considerable saving. This diversity exists because of peaks occurring on different days of the week. On the interconnected system there is no large diversity due to differences in time.

No particular advantage is taken of reserve diversity. Individual companies usually carry spare capacity equal to that of the largest unit; interconnected systems usually carry about 10 per cent of their operating units as spare capacity. In general, it has been demonstrated that the loss of from 25,000 to 50,000 kw. on the system results in less than a 1/10-cycle drop in frequency.

Interconnected companies generally, as a matter of insurance, wish to keep tie lines closed as much as possible. There have been numerous instances in which tie lines have been valuable for emergency interchange upon the occurrence of apparatus failure, operating mistakes, and the like. Excellent relations exist between interconnected companies in such matters, and there have been but very few cases in which special charges were made for such services.

Low water is not classified as an emergency condition because all the major connected systems have water power sufficiently relayed with steam or purchased power. During various periods of fuel shortage, the New England power system, with the exception of the winter of 1917-1918, has been fortunate enough to obtain sufficient fuel for its own plants. It has taken advantage of interconnection by arranging to supply fuel to interconnected steam plants, in return receiving power at prearranged prices.

The use of interconnected lines for economy flow has shown large financial returns, and now, when surplus hydro power or economical steam is available, there is no operation of uneconomical plants excepting in some special cases where for special reasons there is a need of local generation. Almost all companies purchase power when it is to be had for less than local generating costs. The savings from major operations of this sort usually are split equally between the companies participating.

## CONTRACT RELATIONS

Usually no contracts are drawn for other than the purchase of firm capacity, and each company builds the portion of interconnecting lines in its own territory. The interconnected companies of comparable size have established a definite system whereby, based on cost differentials and demands, the generating costs of connected plants can be determined, and interchanges are worked out daily. Under these exchanges there is no guarantee of service but when economic conditions shift unexpectedly it is customary for each company to continue its schedule until, with mutual understanding, adjustments can be made. It is customary also for all companies to assist each other in emergencies.

Plans for interchange usually are made daily, in advance so that definite schedules can be arranged late in the afternoon for the following day. The New England power system dispatcher is in touch with the dispatchers of the adjacent systems and determines the quantities of power which can be furnished or absorbed. These compared with his own sources and costs readily determine the economical set-up for the day, and schedules are arranged.

## DISADVANTAGES AND DIFFICULTIES

One of the major difficulties that has arisen with interconnections lies in the inability to exchange an exact predetermined amount of power with a number of systems at the same time. Careful regulation of speed is of prime importance in this problem. Interchange has been controlled reasonably well by allowing one system to assume responsibility for speed control, each of the other systems taking care of the exchange over interconnections. Considerable work has been done in developing automatic frequency control apparatus which can hold speed much closer than the usual type of steam or hydraulic governor. This method of operation has a further advantage in the maintenance of more exact time for electric clocks.

## JOINT PLANNING OF CONSTRUCTION

The New England power system has had the good fortune to have many alternatives in planning additional sources of power. There have been possible water-power developments of various types as well as a variety of methods of extending steam generating facilities. The development at Fifteen Mile Falls was of such size that it could not be justified without various interconnections to assist in its absorption. Its character is such as to make it a desirable adjunct to any system depending entirely on steam, and this made it possible to sell a large block of power to the Edison Electric Illuminating Company of Boston.

The New England power system load has grown to such a size that the capacity and power requirements for growth should not be studied as a whole but should be divided into three major classes: (1) base load; (2) power or day load of 2,000 hrs. per year; (3) peak and spare capacity. These various classes of load grow about equally on a percentage basis, but the short-hour or peak type of load grows far faster on a quantitative basis. Additional requirements of base steam of the best grade grow slowly, and if this type of plant is increased too far in advance of requirements, it crowds into short-hour use expensive plants designed for better load factor. For the second class, the day load or 2,000-hr. power, it is apparent that plant capacity should be secured for a lesser first cost than for class one. A few hydro possibilities are peculiarly suited to this service. If the hydroelectric plant site affords sufficient storage, permits the power house to be close to the dam, and does not restrict its size, the increment first cost of unusual capacity may be favorable. These conditions existed at the Fifteen Mile Falls development. The water available at this plant, though sufficient to operate at full capacity but 2,000 hours per year, can be used when it is most valuable, and involves a negligible operating cost for additional capacity.

The third requirement of the systems is a capacity suitable for meeting annual peaks and carrying through the year and during the peak period day-to-day spare. The necessity of this sort of facility has been well illustrated by the development of the Rocky River pumping plant of the Connecticut Light & Power Company. The Fifteen Mile Falls plant also is well adapted to supply this type of power. While the older and rather uneconomical steam plants also are suited to this type of service, the cost of being ready to serve for peaks and spare is higher than that of suitable hydro plants. The Fifteen Mile Falls type of plant will confine their use for this purpose to a very small part of the year.

Interconnection has made possible therefore a large development of power of decidedly the type needed on the New England system and which also fitted well into the Edison system but not feasible of development without a very large or interconnected system. It has made the entire output of this development more immediately useful and has put off the construction of further base load steam capacity, which in turn will be desirable of construction in large blocks or more economical absorption later in the combined New England systems.

## FEATURES OF DESIGN

Automatic frequency control apparatus has been installed at three hydroelectric plants on the New England power system in order that it may be possible during a great many hours of the year to have at least one of the plants in position to handle the burden of speed control. Different operating periods for run-of-river plants and storage plants require that automatic frequency control apparatus be installed in both types of stations to insure automatic speed regulation being available practically at all times without departing materially from the normal economic schedule of operation. It has been found that a frequency deviation of not more than 1/20 of a cycle from normal approaches the best possible conditions for load interchange.

The increasing interconnection of transmission lines, together with the increased use and reliance upon electric power, is necessitating always greater reliability and freedom from disturbances. In New England, disturbances originating from lightning present the most formidable problem in transmission line operation. Where justified economically, transmission lines in this district are being built with unusually short spacing of supporting structures to secure a low average height above ground; and overhead ground wires usually are provided. Horizontal construction with single circuit towers and two overhead ground wires are being used generally on all major lines. The natural condition of high footing resistance that obtains throughout New England has been overcome partially by steel grillages for tower footings. Considerable betterment in the performance of transmission lines has been secured by increased insulation and proper line location. Sleet is another formidable foe, and attempt is being made to design major lines to operate through the worst sleet conditions with not more serious troubles than broken conductors. Vertically spaced line designs generally have been abandoned. Considerable use has been made of sleet thawing.

As the result of high speed oil circuit breakers and high speed relays now being installed a considerable improvement in operating conditions is expected. The Fifteen Mile Falls development was equipped with 220-kv. circuit breakers having an over-all relay and circuit breaker operating time of the order of eight cycles (0.13 sec.) and it is hoped to secure similar characteristics in breakers purchased in the future for the lower voltage developments. Tests on the 220-kv. breakers, some of which were taken under actual operating conditions, showed the removal of short circuits in quite a spectacular fashion, with only very small voltage disturbances and a remarkable lack of damage at the point of application of the short circuit. Considerable increase in synchronizing power during the short circuits also was secured.

Experience with this system indicates that the economical application of a high voltage interconnection necessitates such power factor correction as to insure the operation of the high voltage lines at practically unity power factor. Interconnected lines must operate also at a somewhat less drop in potential to avoid voltage variation when the point of feed is shifted on the system. Approximately 180,000 kva. of synchronous condenser capacity is in operation on the New England power system, and has proved justified on the basis of economy of transmission and voltage control. On the New England system there has been no occasion up to the present time that has necessitated the use of load ratio control for shifting load or balancing power between parallel circuits. No-load tap shifting devices have a widespread use on this system; their operation has been so successful that the New England companies were among the first to standardize upon external tap shifting devices for practically all important transformers.

# Pa.-Ohio-West Va. Interconnection

By
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TEN INDEPENDENT operating companies of western Pennsylvania, eastern Ohio, West Virginia, and Maryland operate normally in parallel to secure the manifold advantages of the interconnection of their facilities. Each of the systems has had its own romantic growth from the small local generating plant to the highly developed load area with its network of power lines furnished by modern power stations. It was proper then that these independent neighboring companies should cooperate to realize the benefits of interconnection. These benefits now are being secured, the common understanding of every day problems of parallel operations being secured through the working committee of operating men from each of the ten individual systems.

The territory served by the ten operating companies constituting this interconnected system has an approximate total area of 101,000 sq. miles, and a population of about 9,000,000 including 300 cities and towns of all classes. An estimate of the peak load of this group for 1930 occurring in December between 9 and 11 a.m. is 1,750,000 kw.; the annual load factor is about 70 per cent.

### CONTRACTUAL RELATIONS

Reliability of service, capital investment economy, operating economy, and the stabilization of frequency, voltage, or reactive kilovoltampere conditions on transmission systems, are all represented on the contractual relations of these interconnected companies. Neighboring companies first contacted on the frontiers of their respective systems for the mutual protection of those districts having only one source of power. Ever since 1916 capital investment economies have been secured on these systems by the use of short-time contracts for the purpose of dovetailing the steps in power station building programs. In this manner, the economic waste that goes with building generating stations too far in advance of the individual system load has been eliminated by staggering construction between independent companies.

An example of the combined financing of power stations exists in the Windsor power station owned jointly by the Ohio Power Company and the West Penn Power Company. This station built jointly in 1917 produced all the major benefits of the interconnection of generating facilities as well as many other operating and investment economies. Combined financing of transmission lines also has been secured between the Associated Gas and Electric Company and the West Penn Power Company by working out a program whereby each company constructed sections of high voltage transmission line serving its own system and then tying in with other sections owned jointly by these companies. Five years of perfect cooperation have been the result of this unique arrangement.

A strong transmission backbone now exists throughout the ten interconnected companies, and the whole system is a fine example of how planning and operation can be accomplished safely with a much lower percentage in spare generating capacity than is possible without such interconnection. The reserve capacities are so distributed that what any one system will be called upon to furnish represents in many cases only the overload capacities of the machines in usual operation. Another factor, the protection of service based upon mutual assistance when necessary, is commercially the most important of all the possibilities of interconnection. Several instances of emergency have proved the benefit of this form of protection.

### OPERATING BENEFITS

The study of the problem of reduction in spare generating capacity on this interconected transmission system has resolved itself into two phases; one, the

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Based upon "The Pennsylvania-Ohio-West Virginia Interconnection" (No. 31-103) presented at the A.I.E.E. summer convention, Asheville, N.C., June 22-26, 1931.

utilization of the operating or spinning reserve capacity of the generating units, and the other, the coordination of the operation of the reserve capacity between these various companies so as to carry the required spinning reserve in the most economical manner. The resultant diversity by combining spinning reserve capacities makes possible a decrease in the total reserve capacity in service without the loss of reliability, and the proper proportioning of the spinning reserve capacity between the component parts of the system materially decreases the amount carried on any one system. On this interconnected system it is believed that the spinning reserve carried by any one company should be 10 per cent of the load carried by a steam station and 5 per cent of the load carried by a hydro station. When any one company generates more than 20 per cent of its load on any one steam unit, it should carry as its portion a spinning reserve equivalent to 50 per cent of the load on this unit. Each of the two metropolitan systems serving Cleveland and Pittsburgh with their adjacent territories carries its own reserve, equal to the largest unit on its system. These urban systems follow the practise of holding this reserve only in the overload and less efficient capacities of the generating equipment actually in operation.

Windsor station, being the central point of the interconnected system, acts under supervision of the working committee as a clearing house for all data on existing reserve capacity. Any changes in spinning reserve capacity desired by one of the companies are transmitted to the Windsor dispatcher. In no case is the spinning reserve deficient for more than two hours. If an accumulation of circumstances causes the required spinning reserve to be decreased by more than 25 per cent, the Windsor dispatcher at once has a check made of all possible reserve, and if the actual spinning reserve is not equal to at least 7½ per cent of the then total system peak, he requests that additional capacity be placed in service at the most convenient location as soon as possible. Through the proper use of this reserve generating capacity the interconnection has wrought such wonders that the public is often unaware that trouble has ever occurred.

The tying together of small communities within the same system commonly results in a large saving due to load diversity; however, it has been found that the

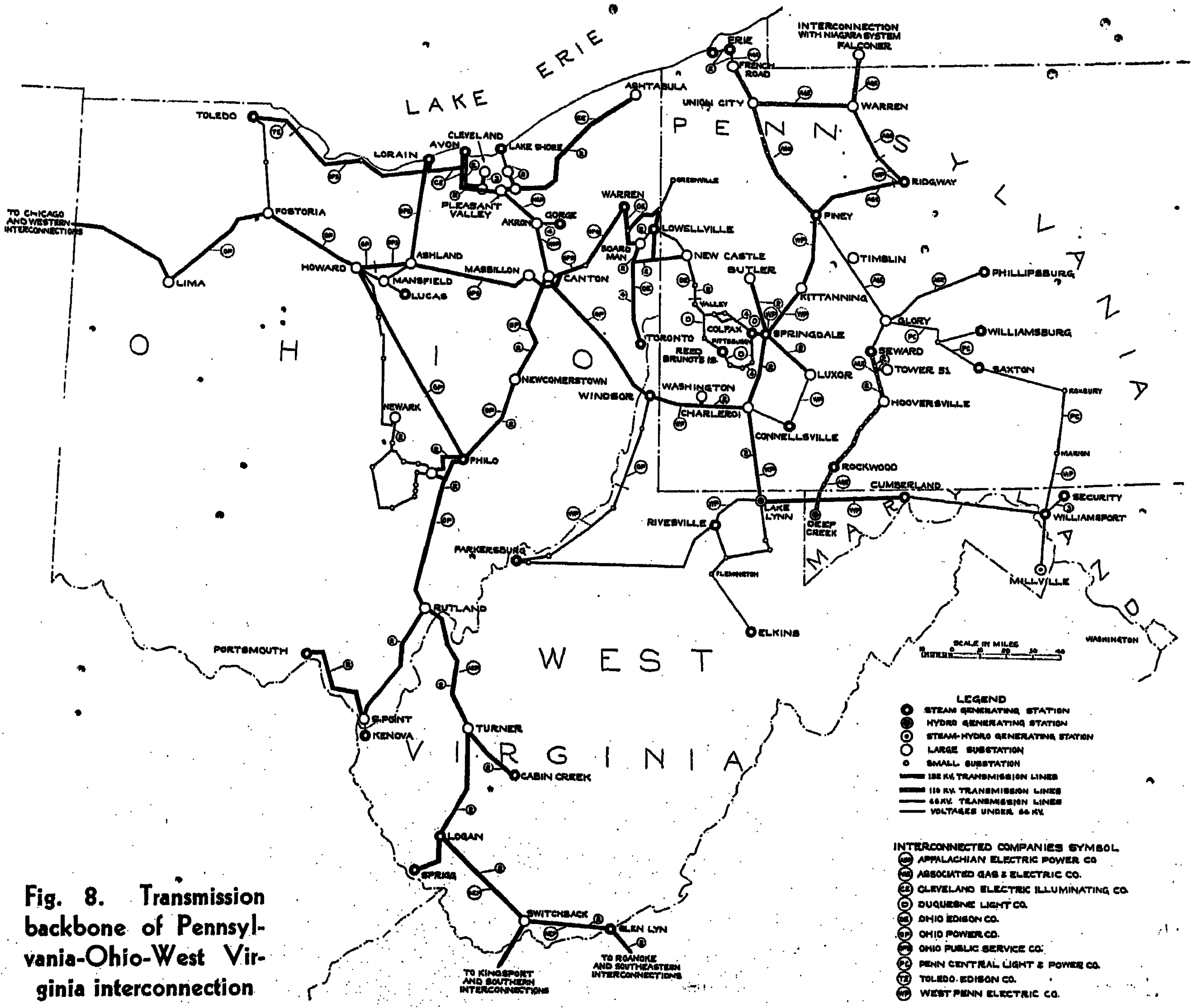

**Fig. 8. Transmission backbone of Pennsylvania-Ohio-West Virginia interconnection**

interconnection of large systems does not produce this same diversity saving. A typical case is that of the western part of the interconnected system on which, with a system peak of 490,000 kw., the diversity between the four individual systems was only 15,000 kw. or 3 per cent.

The expected diversity between industrial and lighting loads cannot always be secured, as there are times when the evening peak of the groups serving essentially industrial systems approaches within 8 per cent of the morning peak. Also, the low water conditions prevailing since November 1929 create an evening peak for the steam stations. The diversity in the industrial load itself has increased noticeably during the last two or three years, no doubt due to the use of off-peak power by many industries. The difference in time between sections of the interconnected system is scarcely noticeable in the group as a whole.

Fig. 9. View of switchboard room and load dispatcher's headquarters at Windsor station

## STABILITY

Installation of the 132-kv. transmission backbone and care in the selection of characteristics of equipment at the terminals, have caused instability to be no longer the serious problem that existed with earlier interconnections. As Windsor is the center of all interconnected operations, so is this station the center of the stability problem. The generators at Windsor are of the large air-gap type with a high short-circuit ratio, requiring a heavy no-load magnetization. Consequently with full excitation and no-load a low maximum voltage is indicated. These machines are not much affected by load changes and are inherently stable. The voltage regulators at Windsor are of the Tirrill type, one per exciter direct connected to its generator. From the standpoint of stability this arrangement of exciters is satisfactory, since steam units do not overspeed to any great extent. The voltage regulators operate in parallel through the usual compensating coils which force a correct sharing of the reactive kilovoltamperes. Automatic frequency control normally operates upon three units.

Throughout its history the Windsor station has stood like a rock against the many momentary surges transmitted to it from the east or the west. It has handled successfully many rapid load changes on the order of 50,000 to 90,000 kw. The problem of stability on each system is mainly staying in synchronism with Windsor.

East of the Windsor station a main transmission line extends 41 miles to Charleroi substation, from which a main transmission line extends south to the Lake Lynn hydroelectric station, and north to the Springdale steam-electric station. Most of the eastern parts of the interconnected system are tied in at these two last named stations. The synchronizing power of the lines between Windsor and Springdale, and between Windsor and Lake Lynn, is 500,000 kw., which is ample to hold these stations together. The generating units at Lake Lynn and Springdale have a low short-circuit ratio.

An unusual situation exists between two of the systems which are so tied together through autotransformers with dead-grounded neutral that either system may receive ground fault disturbances from the other. However, so far no difficulty has been encountered from these connections.

The most vulnerable point of this eastern system is near the Springdale station where there is a short-circuit capacity of 1,200,000 kva. Calculations indicate that a three-phase short-circuit fault must be isolated within 16 cycles or the units are likely to go out of step. A severe case of dynamic instability on the occurrence of a fault on both of the two 132-kv. lines near Springdale caused two generators to trip out on overspeed. Following this the excess voltage protective devices of the voltage regulators at Springdale were removed from service, and the subsequent occurrence of a more severe short circuit caused no generators to be tripped out of service.

In several instances the high power factor and low generator short-circuit ratios at Springdale have caused the operators to place a leading power factor upon a generator during load shifting, with the result that the generators fell out of step, without however interrupting service.

The interconnected systems to the west of Windsor station are somewhat more extensive and complex; certain of the lines form a 250-mile high voltage transmission ring involving five power companies with a total generator capacity of nearly 1,250,000 kw. Occasional operation with this ring closed on itself has demonstrated the inflexibility of interchange control, and therefore the loop is left open. Comparatively few cases of static instability has been reported on any of the interconnected systems.

The regulation of the flow of reactive power and the distribution among generating units is not a problem on this interconnected system. This is due largely to the high power factor maintained on lines and generating stations, made possible by the character of the load and the synchronous condenser capacity located at the transmission substations. On the systems of the West Penn Power Company and the Ohio Power Company alone there is synchronous condenser equipment totaling 172,500 kva. not including the generating units at hydroelectric stations which may be operating with low gate opening. The voltage of the generating units at the principal power stations is held practically flat, there being not more than a 3 per cent variation between light and heavy load. Load ratio control equipment is used to a limited extent to give control of the reactive current.

### FREQUENCY AND POWER FLOW CONTROL

Close regulation of the load among the interconnected systems of this group and among the individual power stations of each system has been a most difficult problem. It has been necessary for the working committee to hold many meetings to analyze these problems and determine a common basis for action. These meetings have been followed by continual educational work among the load dispatchers and switchboard operators until satisfactory operation has been accomplished.

Early in 1929 the working committee decided that Windsor station with six 30,000-kw. generators be assigned the task of holding a deviation from 60-cycle frequency of less than 1/20 cycle. As no automatic frequency control equipment had been installed, one operator on each shift was assigned to the duty of holding steady frequency by adjustment of the six governors. Operators in the other stations were instructed to disregard frequency entirely and concentrate on maintaining a close adjustment of tie-line load. The success of this new scheme of operation is indicated by the fact that whereas it had been the usual practise to adjust tie-line loads three or four times an hour, three or four times a morning, afternoon, or evening then sufficed.

In 1930 automatic frequency control equipment with an adjustment range of 0.25 cycles plus or minus was installed. Although arranged to control all six generators, it was found that with normal operation three or four generators were adequate to hold the system frequency to within 1/40 cycle of 60 cycles.

After a year's study of frequency regulation by Windsor station only, it was found that the only real difficulty of this scheme of regulation occurred at the periods of day when the load was shifting rapidly as at 7 a.m., the noon hour, and 6 p.m. Additional automatic frequency control equipment is now being experimented with at other stations. Preliminary tests would indicate that the objective has been achieved.

# Forecasting Population for Engineering Purposes

**Population forecasts, when carefully and intelligently made, serve a valuable purpose in helping to direct the employment of labor and capital to places or projects where they are most needed. Such forecasts cannot be based on formulas, but require careful weighing of many related factors.**

By
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ENGINEERS and persons responsible for the management of engineering projects have a common interest in problems of forecasting population growth and market demands. The soundness of engineering projects depends upon their capacity to fulfil a real demand; unsoundness or even failure may result from planning and designing engineering projects without regard to industrial and population trends. Similarly, city planning, housing and home building projects, and educational and social programs of various kinds ordinarily should be based upon the number of people to be served at some future date and their economic and social characteristics.

Within the Bell System the careful study of factors influencing the growth, distribution, and character of the population is regarded as essential to the intelligent planning of the telephone business. Engineers are provided with forecasts of the probable telephone service requirements at periods ranging from five to twenty-five years into the future; on the basis of these and other pertinent factors, the initial and ultimate size of buildings, switchboards, underground cables, and the pole lines and aerial cables are determined. In planning for the future, the central aim of the telephone company is to supply the right amount of facilities in the right place. Manifestly this cannot be done except when based upon dependable forecasts of population and its distribution.

Several mathematical formulas have been devised on the assumption that future population can be determined from past trends by the mere application of figures in the formula. It is believed, however, that such formulas place too much emphasis upon past

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Based upon "Forecasting Population for Engineering Purposes" (No. 31-138) presented at the A.I.E.E. South West District meeting, Kansas City, Mo., October 22-24, 1931.

trends, ignoring the fact that new influences are always appearing and that old influences are frequently ceasing to be of importance.

Cities and regions grow not from mere wishing or boasting, but usually because of definite geographic and economic advantages which enable them to develop population supporting activities in competition with other localities. Forecasts are apt to miss the mark rather widely if the forecaster has only a local point of view. A national outlook eliminates the optimism based upon the pride of those born or residing in the particular locality for which the forecasts are being made, and the conclusions reached by a broad point of view undoubtedly are much more likely to be realized.

### POPULATION OF THE UNITED STATES AS A WHOLE

Because communities are competing with each other, population forecasts for states and for individual cities should be made with due regard to population trends of the country as a whole. Some of the facts and tendencies that have a definite bearing upon the population growth of the United States may be summarized briefly as follows.

The United States is almost certain to continue a restrictive immigration policy for many years to come. Until the last decade, immigration contributed heavily to our population growth. This is clearly evident from the 1930 census figures which showed that foreign-born whites and their children constituted 31.1 per cent of the country's total population. In the future, population increases must depend more and more upon the excess of births over deaths.

The birth rate in the United States has been declining gradually for several years, due to such factors as generally higher living standards, smaller living quarters, marriages in which both husband and wife are breadwinners, the tightening of immigration restrictions against the prolific races, and finally wider knowledge and utilization of birth control information. Although there have been reductions in infant mortality, the effect has not been sufficient to prevent a decline in the rate of natural increase. For example, in 1910 the birth rate was about 30 per 1,000 population and the death rate was 15, while at present the birth rate is very close to 19 and the death rate about 12. Thus, in twenty years the margin which represents natural increase in population has decreased from 15 per 1,000 to 7.

The number of people in continental United States in the last forty-year period together with increases in each ten-year period is indicated in Table I.

The gain during the 1920-1930 decade exceeds by more than one million the largest previous gain, that occurring in the period 1900-1910, and it is 3.3 million in excess of the growth realized in the decade just preceding, that is, from 1910 to 1920, when the net immigration was 25 per cent greater and the rate of natural increase some 10 per cent higher. A partial explanation of this seeming inconsistency is in the probable greater efficiency with which the 1930 count of inhabitants was made. Furthermore, the period of counting for the 1910-1920 decade was some six months shorter than that of the 1920-1930 decade. It seems evident that the natural rate of population growth has been steadily slowing down, and that the same general tendencies will prevail over the next twenty years.

### TREND FROM COUNTRY TO CITY

Now the slackening in the rate of population growth for the country as a whole naturally will be reflected in the population increase to be divided among urban and rural communities. Unless a community is relatively better situated than in the past, it cannot expect to maintain its past rate of growth. This is emphasized by the increasing mobility of the American people who always have been peculiarly ready to move in response to economic activity. The development of improved means of communication and transportation and the rapid spread of comparative information have accentuated this mobility. Thus the real advantages or disadvantages of communities are likely to play a more important role than heretofore in determining their relative capacities to attract or to hold a population.

Urban population has been increasing at a far higher rate than rural population. During the past decade the increase in the rural population was 2.4 millions as against 14.6 millions for the urban centers. Whereas the 1900 census reported only 40 per cent of the population as urban, the corresponding figure in 1930 was 56.2 per cent. This tendency is related intimately to fundamental economic changes, including the capacity of the farms to maintain a rapidly increasing urban population, and the transfer to the cities of many labors that formerly were a part of farm work. Contributing factors lie in the tendency of our export trade to shift from raw materials to manufactured commodities, the increasing per capita demand for these products in this country as a result of the rising standard of living (a tendency that is temporarily obscured by the present general business depression). Further contributing facts are in the additional opportunities for untrained workers in the cities brought about by both the decrease in foreign labor supply after the drastic restrictions on immigration went into effect and by the unusual growth in the service industries.

Further scrutiny of the census figures indicates that in general the larger cities in the country are growing more rapidly than the smaller cities. Between 1920 and 1930 the total growth of the ten largest cities in the United States, including their suburban territories, accounted for approximately 40 per cent of the total population increase of the country. The entire group of cities of over 10,000 population obtained 68 per cent of the country's total increase; and if the suburban areas of cities of over 50,000 population were included, the proportion would be raised to 86 per cent. Not only has urban population been increasing at a far higher rate than the rural population, but the tendency is one that probably will continue into the future.

### FORECASTING POPULATION OF A STATE

A series of economic surveys was made by the Southern Bell Telephone Company between 1924 and 1930 with a view to providing a more or less definite picture of economic conditions and trends in the five states in which it operates. The general plan of these studies involved an analysis and presentation of the following subjects:

1. Natural features, including a study of land form, soils, climates, vegetation, and water resources, with respect to their influence on activities.
2. The situation and outlook of each state's basic industries—agriculture, manufacturing, lumbering, and mining—in relation to population.
3. The comparative conditions and prospects in the various natural or economic-geographic regions of the particular state, the regional treatment being essential because of the dissimilarity of conditions prevailing over most states.
4. A detailed analysis of the situation and outlook of the principal cities.
5. The effect of the probable population changes upon the demand for telephone service.

Illustrative of the kind of questions for which answers were sought by the state economic surveys are these: How will the expansion (or perhaps contraction) of agriculture be distributed over the state? Will farmers have a greater or lesser purchasing power? What is the manufacturing outlook in the state? What kind of manufacturing activities may be expected to expand and what about their localization? Will the increase in the population-supporting activities be sufficient to cause the state to attract large numbers of persons from other states?

Personal inspection tours of each state were considered essential, following the collection and careful review of such information as was available. Contacts had been established with organizations and bureaus throughout the area, and during the inspection trips interviews were possible with persons in many lines of work. Of course all of the material and suggestions gathered in this manner could not be accepted at face value since local pride and enthusiasm were not always restrained.

### FORECASTING THE POPULATION OF A CITY

By the nature of things, no two cities present situations precisely alike; indeed, one of the most striking facts is their dissimilarity. However, in analyzing the past growth of a city and forecasting its future, there are usually five principal influences to be considered:

1. Size and character of its tributary trade territory
2. Its industrial expansion
3. Its attraction as a home center
4. Governmental activities
5. Institutional activities

**Table I—Continental United States**

| Year | Total population | Increase during previous decade |  |
|---|---|---|---|
|  |  | Number | Percent |
| 1890 (June 1) | 62,947,714 |  |  |
| 1900 (June 1) | 75,994,575 | 13,046,861 | 20.7 |
| 1910 (April 15) | 91,972,266 | 15,977,691 | 21.0 |
| 1920 (January 1) | 105,710,620 | 13,738,354 | 15.0 |
| 1930 (April 1) | 122,775,046 | 17,064,426 | 16.1 |

Study of the trade territory of a city is essential to an analysis of the population supported or likely to be supported by the wholesale, retail, and general office business of a city. This territory usually can be defined with the aid of an analysis of banking relationships, newspaper circulation, and the distribution of sales of representative wholesale establishments.

The trade territory of practically every city is changing, increasing or decreasing in extent and also undergoing changes in the character of the population. In respect to the latter, it should be remembered that the importance of a trade center depends not only upon the number of people in the tributary area but also upon their standard of living. In an analysis of the probable future changes in the trade territory of a city, consideration must be given to the trend in agriculture and industry, including such factors as improved highways, motor trucking, and changes in freight rates.

### INDUSTRIAL EXPANSION

It now appears that the growth of most of our cities during the next twenty years will be due primarily to their relative attractiveness for industrial expansion. For purposes of population analysis, it is helpful to classify industries. They may be grouped according to those which attract population, such as steel mills and automobile factories, and those which result largely from the presence of population, such as bakeries, laundries, and ice cream factories. Again, it is helpful to consider industries from the standpoint of whether they are conservative or exhaustive in nature; that is, whether their supplies are continuous or temporary. The lumber industry as it has been carried on in this country is a striking example of an exhaustive industry; in many places, industries (such as oil refining) based upon the presence of minerals are exhaustive.

If a city has diversified manufacturing plants, its growth is likely to be more uniform or stable than for a city where a single industry is dominant. It is well to note that different industries do not contribute to the population of a city in exact ratio to the number of employees. In a number of industries including the manufacturing of shoes and clothing a large proportion of the workers are girls and women, representing second and third members of a family. Further, one must consider the effects of labor-saving machinery. In the past virtually all industries have been able to increase their output by the application of labor-saving devices without a proportionate increase in the labor required, and it is certain that this tendency will continue.

There are many people who choose a place to live rather than a place to work. Among these are the independently wealthy, the retired, and the adventurers. These people seek living conditions to meet their desires, and adjust their occupations if necessary to what is attainable where they choose to live. The classes who seek places to live first and occupations afterwards are likely to increase in the future.

The national capital and many of the state capitals owe their growth primarily to the activities of the federal or state governments. In the past there has been a general tendency to enlarge the functions of governments, but for the immediate future it seems reasonable to expect an increasing pressure for more economical governmental administration expansion.

### EFFECTS OF INSTITUTIONS

Many cities in the country have military establishments, educational institutions, penitentiaries, etc., which add considerable numbers to the population. Sometimes institutions of this character are relatively so large and subject to such wide fluctuations in size that they tend to render past rates of growth of the city misleading, and to make forecasting of the future extremely difficult. In analyzing the population growth of such cities it has been found advisable to isolate the past population related to institutions and treat this influence separately in forecasting the future.

Many cities possess the advantages just described in more or less equal measure, yet their past and prospective rates of population growth vary widely. It is here that well-directed effort on the part of various civic bodies is important. The community which effectively advertises its natural advantages of location is likely to grow while a neighboring city equally well situated may stand still or even decline. Civic spirit is therefore a proper consideration in every population forecast. Through advertising activities a few of our cities have attracted a larger population than they can hold, and the slump which is bound to follow will perhaps permanently injure them. On the other hand some cities probably have retarded their growth by advertising which so glaringly exaggerated their attractiveness that their real advantages were overlooked.

In the telephone business, and in most other businesses where advance planning is required, it is important not only to know the probable growth of population, but also its character and distribution, and its division into family units. Future population growth is forecast upon the basis of certain definite factors already cited, including expansion of industry or commercial activities which support population. In estimating the amount of population that probably will be located in high grade, medium grade, and poor sections of the city, it is essential to know rather definitely the class of population supported by the various activities. Further, it is well to note that each part of a city is in competition with other sections of the city for the limited population growth of the whole community in much the same manner as cities compete with each other.

# Abstracts

## Of Papers to be Presented at the Milwaukee District Meeting

INTERPRETIVE abstracts of all papers to be presented at the A.I.E.E. Milwaukee District meeting (March 14-16, 1932) are presented herewith. Members vitally interested and wishing to obtain immediately pamphlet copies of any available papers are requested to use the order form appearing on p. 222 of this issue. In response to popular demand and within its space limitations ELECTRICAL ENGINEERING subsequently may publish certain of these papers, or technical articles based upon them.

### A General Method of Gaseous Tube Control

By
C. Stansbury[2]

METHODS devised for the purpose of controlling the mercury vapor rectifier tube by means of the hot cathode grid have been produced in much profusion for the past several years. However, certain novel control methods which it is felt are based upon fundamental ideas and should be of general engineering interest are presented in this paper.

It is shown that the inherent rectifying property of the cathode grid circuit lends itself to condenser-energy-storage methods of grid control which may take a number of forms. A typical set of control characteristics for a tube of the type described is shown, in connection with which it is pointed out that the response to grid voltage varies rather widely at different temperatures of the condensed mercury in the tube, except for anode voltages in the neighborhood of that at which the tube just starts with zero grid potential. This anode voltage is quite constant except at tube temperatures outside the normal working range, so that methods of control which take advantage of this fact give response comparable in accuracy to that of the high-vacuum tube. Various control circuits based on these principles are shown and described. (**A.I.E.E. Paper No. 32M6**)

## The Proximity Effect and Its Application to the Concentration of Heating Currents in Predetermined Strips

By
Edward Bennett[1]

IN ANY industrial operation such as welding, concentration of heating currents in particular parts of the metal presents obvious advantages. A method is described in this paper of concentrating these heating currents in predetermined strips of conducting plates, pipes, or other shapes. These are placed in close proximity to each other or to auxiliary conductors. They are so interconnected that heating currents concentrate largely in adjacent strips in close proximity to each other and in which the current flows in opposite directions. The shapes are connected with sources of alternating or oscillatory current of moderately high frequency. The method therefore consists in the use of an enhanced "proximity effect" to control the distribution of heating currents in bodies.

Mathematics and theory to assist in the solution of this problem are presented in the paper. Curves have been worked out to illustrate the control of the distribution of the heating current densities by means of this proximity effect. Unquestionably the control of the distribution of heating currents which is thus made possible opens up a new range of industrial heating effects. The method of selectively heating bodies by causing the heat energy to be generated in the body in strips of predetermined width and depth would seem to give a hitherto unattainable nicety of control of the distribution of temperatures in metallic bodies. (**A.I.E.E. Paper No. 32-54**)

## Electrical Instruments in the Gas Industry

By
E. X. Schmidt[2]

OPPOSITION to the use of electrically operated devices in the gas industry has disappeared because of the outstanding advantages of many forms of electrical control apparatus. Although the control of gas pressure generally is still mechanical, the flexibility and sensitiveness of electrical pressure controllers has made these devices a valuable asset in the distribution of gas. Thermal meters, calorimeters, and total heat meters are among those to which electrical devices are applied. The Thomas thermal meter makes possible the automatic measurement of gas flow at standard conditions independent of variations in the temperature, pressure, and saturation condition of the gas. The Thomas calorimeter, a device comprising an unusual combination of mechanical and electrical parts, provides a means for recording gas quality; while the Thomas total heat meter, an electrical combination of the above instruments, gives a direct measurement of the energy in the gas.

Heating values within 1 per cent, plus or minus, of a fixed value generally must be maintained. Therefore a calorific instrument designed for control purposes was developed. It is particularly useful for the automatic control of mixing two or more gases of unlike heating value to obtain a mixed gas of constant heating value.

The most recent development in the gas industry is the fully automatic gas plant for small communities. These plants are electrically operated and controlled, providing an uninterrupted supply of gas of constant heating value at constant pressure, a service which compares very favorably with that formerly enjoyed by large communities only. (**A.I.E.E. Paper No. 32M10**)

## Toll Switching Plan for Wisconsin

By
W. C. Lallier[3]

DEVELOPMENTS of telephone plant and technique have extended constantly the distance over which it is technically possible and commercially practicable to furnish toll telephone service. The result of this extension in the range of transmission has been to increase the number of possible commercial toll connections and to stimulate growth in toll service. In this paper, the toll switching plan for Wisconsin including some features of the transmission design requirements and the present and proposed toll cable network is outlined briefly. The relationship of the plan to that for handling countrywide toll connections also is touched upon.

It is found that the toll cable type of facilities gradually is supplementing or replacing the open wire type along many of the important routes of the system. It is expected that ultimately the use of open wire lines will be limited largely to the feeder and branch routes to cities and towns located some distance from the main toll cable route. A large majority of the principal open wire lines in Wisconsin now are arranged to have superimposed carrier systems operating upon them, and this application has been an important factor in providing for the increased toll traffic during the last few years. (**A.I.E.E. Paper No. 32-55**)

## Police Teletypewriter Communication

By
R. E. Pierce[4]

POLICE organizations throughout the country are rapidly adopting the latest development in record communication, namely, the teletypewriter. By this means alarms are typed at one point and simultaneously recorded in printed form at a large number of widely separated stations. The engineering for a modern police system involves not only the provision of the teletypewriter machine, but large networks of telegraph circuits with the associated switchboards, telegraph repeaters, power plants, and testing equipment which also must be designed, manufactured, and installed.

In adapting the teletypewriter to police work, some interesting problems have arisen. Usually service is of an intermittent nature and special arrangements are provided at the sending location for starting and stopping the distant teletypewriter. Also specially designed control arrangements are provided to allow an operator at general police headquarters to take control of an entire state network, including all groups of stations which normally would operate individually. In other cases an acknowledgment circuit is provided for advising the sending operator when a message has been received at a particular station. In certain types of offices where a number of stations is on one circuit, selective calling devices allow any one station to select any other station or group of stations on the circuit. Various types of leased networks are designed to fit particular needs of police organizations. (**A.I.E.E. Paper No. 32M8**)

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[1] University of Wisconsin, Madison.

[2] Cutler-Hammer, Inc., Milwaukee, Wis.

[3] Wisconsin Telephone Co., Milwaukee.

[4] American Tel. & Tel. Co., New York, N. Y.

## Weather Resistant Insulation for Line Wires

By
C. F. Harding[5]
L. L. Carter[5]
J. W. Olson[5]

GREAT ADVANCES have been made in the art of producing insulation for higher voltage cables, but it is only within the last two years that any unified and organized attempt has been made to improve the weathering and insulation qualities of the covering of weatherproof line wire. The relatively high cost and poor operating performance of weatherproof coverings on overhead lines of 4,000 volts and less, indicated the necessity for taking steps to improve the weatherproof covering or to discontinue its use entirely.

Complete testing equipment for determining the comparative life of different weatherproof wire covering was purchased or constructed for the laboratories at Purdue University. This very complete equipment has enabled a large number of conclusions to be drawn, the most important of which may be summarized briefly as follows:

1. The present triple-braid weatherproof wire covering may be improved materially by the use as saturants of higher fusing point blown asphalts, free of waxes and low boiling fluxes. Such a saturant will provide a covering of uniformly long life.

2. That the higher saturating temperatures required to apply such saturants may be used without damage to the cotton yarns or excessive annealing of the copper conductors, has been proved.

3. Specifications for weatherproof coverings soon will be written as a result of this work, the terms of which will guarantee weatherproof wire of long life.

4. Future work will provide a covering of lighter weight and smaller size, but of higher insulating value and longer life than does the present construction. (**A.I.E.E. Paper No. 32-56**)

## Development of the Waukegan Station of the Public Service Company of Northern Illinois

By
J. L. Hecht[6]

REASONS for the choice of site, general plan, and development of the Waukegan station are outlined briefly in this paper, further details being given in a companion paper by E. C. Williams. This station, located approximately 40 miles north of Chicago and on the west shore of Lake Michigan, has an installed capacity of 290,000 kw. It performs the dual function of supplying energy to a metropolitan system and a surrounding transmission system.

Following a careful study, the Waukegan site was acquired by the company in 1917, and subsequent developments have proved the desirability of this location. The first development period for the station was between 1922 and 1925, and consisted of a 25,000-kw. unit and a 35,000-kw. unit, both operated at 350-lb. pressure, with a total temperature of 675 deg. fahr. with no reheat.

During the second development period, between 1927 and 1930, a 50,000-kw. unit and a 65,000-kw. unit were added, the operating steam pressure being raised to 600 lb., with a total temperature of 725 deg. fahr. In the third period, just begun, a 115,000-kw. unit was placed in service September 1, 1931. At this time radical changes in switching arrangements were made. Considerable increase in the size of the station is anticipated for the future. (**A.I.E.E. Paper No. 32M9**)

## Electrical Design Features of Waukegan Station

By
E. C. Williams[6]

DEVELOPMENT of the Waukegan station through the three periods outlined in the companion paper by J. L. Hecht is described in the present paper. Details of the changes and the reasons for them are given.

The tendency toward metalclad switchgear in the development of this station is especially striking, the first 132,000-kv. switchgear of this type ever used having been placed in service as part of the installation for generating unit 5. This generator and its transformer operate as a unit without connection to the low voltage bus.

A number of interlocks on the switching and instrument transformer equipment is provided to prevent operating errors and to protect personnel. Also in designing the control and protective system for the automatic combustion-control equipment used with pulverized coal, unusual care was necessary to insure successful operation. Excitation equipment for the generators was designed to give economical and reliable operation. The paper outlines carefully the changes in practise, the novel applications of standard a-c. motors, the trend toward equipment providing greater safety for the operating personnel, better investment economics, and greater facilities of installation that have occurred at Waukegan station over a period of ten years. (**A.I.E.E. Paper No. 32-57**)

## 115,000-Kw. Turbo-Alternator

By
R. B. Williamson[7]

DUE TO the increasing use of large single-shaft steam turbine units, it has been necessary to design very large generators operating at 1,800 r.p.m. The present paper describes a 115,000-kw. unit recently placed in operation. The generator is wound for 18,000 volts and the whole output of the machine, with the exception of a small part used for the operation of auxiliaries, is stepped up to 132 kv. All switching is done on the high voltage side of the transformers. Therefore it was possible to design the generator for a voltage that would permit a simple two-conductor per slot winding.

Because of the great axial length of the machine, ventilation required careful study, and a new scheme of rotor ventilation was developed to secure uniform cooling throughout the length of the long rotor body. The stator ventilation is of the inward-outward parallel-flow type with fourteen parallel paths in each half of the stator.

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[5] Purdue University, Lafayette, Ind.
[6] Public Service Co. of Northern Illinois, Chicago.
[7] Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Air circulation is provided by four single-inlet motor-driven blowers mounted under the generator. A fin type radiator cooler is mounted under the generator yoke and condensate is circulated through the cooler. Excitation is furnished from a 350-kw. 250-volt coupled, shunt-wound exciter, and a 7½-kw. overhung pilot exciter is used for the field of the main exciter. **(A.I.E.E. Paper No. 32-58)**

## The Mercury Arc Rectifier Applied to A-C. Railway Electrification

By

O. K. Marti[7]

THE BASIC principle of grid control used in connection with large mercury arc power rectifiers is reviewed briefly in order to explain a new application of rectifiers which was made possible by these improvements. This application is described, and it is shown how by its use a single-phase motor for a-c. railway electrification service with series-motor characteristics and for use on any commercial frequency can be designed. With the grid-controlled rectifier it was found possible to eliminate the commutator of the motor and practically all the expensive controlling, switching, and reversing equipment commonly used on a-c. locomotives. The data and layout of a 1,000-hp., 50-cycle, 15,000-volt, single-phase locomotive are given.

The experiments carried out on a locomotive with this type of motor have demonstrated the practicability of the scheme. Besides the advantages from the point of view of locomotive operation, this scheme makes it possible to use a power supply of any available frequency, whereas at the present time frequencies of 25 cycles or less generally are required. While it is too early to predict to what this development may lead, the already apparent marked advantages of a locomotive equipped with this type of motor, may revolutionize the practise of railway electrification.

## Mercury Arc Rectifier versus Rotary Converter Automatic Railway Substations

By

O. M. Ward[8]

EXPERIENCE in the operation of unattended, automatic, mercury arc rectifiers and rotary converter substations supplying 600-volt d-c. energy to overhead trolleys in interurban territory is discussed in this paper. Operating records covering a three-year period from November 1, 1928, through October 31, 1931 are presented for three mercury arc rectifiers, and two rotary converters of comparable size and operating under similar conditions.

As these rectifier stations were among the earliest installations with full automatic control in unattended substations, while full automatic rotary converter substations have been in service many years, it is manifestly unfair to compare these two types of stations for the first year or two of operation. Decided improvements have been made in rectifiers, and the 1931 record therefore may be assumed to be more indicative of normal performance. On this basis the records show that under conditions of operation existing in the Milwaukee interurban territory, the following conclusions may be drawn.

1. There is practically no difference in operation and maintenance costs of the two types of converting equipment, taking into consideration the higher efficiency of rectifiers.

2. Service availability of rotary converters is slightly higher than service availability of rectifiers when the converting equipment is unattended and equipped with automatic control.

3. Rectifiers have not been responsible for complaints from telephone companies or radio users.

4. Control system failures in whole or part are vastly more serious in automatic than in manually controlled stations.

5. More attention should be given to auxiliary relays, operating coils, protective equipments, etc., used in automatic control systems, to insure against faults in them. **(A.I.E.E. Paper No. 32M7)**

## The 60-Cycle Primary Transmission System of the Milwaukee Electric Railway and Light Company

By

C. D. Brown[8]

E. W. Hatz[8]

THE PRIMARY transmission system described in detail in this paper operates at 132 kv. and 66 kv. to transmit bulk energy from generating stations to step-down substations, and to interconnect the system of the Milwaukee Electric Railway and Light Company with hydroelectric plants in the northern peninsula of Michigan. The system is divided into power areas which are served directly from a generating station or from a step-down substation located near the load center of the area. Energy is distributed from these points over secondary transmission lines.

Tower lines are constructed where feasible on existing right-of-way of the electric railway system. High voltage lines are brought into the congested portion of the city over private right-of-way. Four types of tower line construction have been developed, three of which are used in special cases where lines are constructed on a railway right-of-way not sufficiently wide enough to permit the use of standard square base towers. This construction permits the conductors to be carried over the operating tracks of the railway system. The particular type of tower to be used is a question of economics determined by the cost of real estate at that particular location. The system is so planned that it is capable of indefinite expansion without major changes in existing equipment. **(A.I.E.E. Paper No. 32M3)**

## Insulator Sparkover

By

W. L. Lloyd, Jr.[9]

SPARKOVER strength of the various parts used for the insulation of modern high voltage transmission systems has been subjected to a detailed study, the results of which are presented in this paper. Line and station insulation, and bushings used on the station equipment, were subjected to tests to determine their sparkover strength under a wide variety of conditions.

Data are presented for both 60-cycle sparkover and lightning sparkover voltages, and all values have been corrected to an air density of unity. Considerable attention has been devoted to the effect of humidity and a number of interesting results have been obtained. These are shown in a group of tables and curves presented in the paper. Considerable data also are presented on the effect which smoke, steam, dew, fog, rain, and surface dirt and moisture have on the sparkover voltages of insulators. (A.I.E.E. Paper No. 32-59)

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[8] The Milwaukee Elec. Ry. & Lt. Co., Milwaukee, Wis.

[9] General Elec. Co., Pittsfield, Mass.

# An Improved Type of Limiting Gap for Protecting Station Apparatus

By A. O. Austin[10]

A COMPARISON of the impulse flashover characteristics of various forms of protecting gaps and of station insulation shows these characteristics to vary widely for different degrees of overpotentials. In the usual type of protecting gaps, little or no provision has been made for adjustment in order to have the arcing characteristics of the gap conform to the insulation for the range of transients encountered in practise.

A new form of protecting gap, the polarity and time lag characteristics of which can be adjusted over a wide range has been developed, and in this article is compared to the usual form of protecting gaps. The advantages of this improved type of gap in providing protection for a wide range of transients, and at the same time reducing unnecessary discharges of the gap to a minimum, are shown by tests wherein the effect of time lag is quite evident. The advantage of equipping the protecting gap with a fuse or other device is more apparent where a lightning arrester is not present to take most of the discharges.

The advisability of using a limiting gap to protect station apparatus from flashover under very severe overpotentials, in combination with a lightning arrester to relieve equipment of the majority of transients of lower magnitude, is suggested as a means of providing increased protection, at the same time reducing interruptions to a minimum. The use of the control type of protecting gap is proposed as a means of more easily coordinating station insulation on new as well as existing installations. (A.I.E.E. Paper No. 32-60)

# Design and Ecomomic Selection of Suspension Insulator Assemblies

By J. J. Torok[11]
C. G. Archibald[12]

A SUMMARY of data from extensive impulse and 60-cycle laboratory flashover tests upon suspension insulator strings relative to unit shell diameter and unit spacing is given in this paper. The insulating qualities and the economic advantages of the various sizes of units are discussed with due regard to the most recent lightning protection theories. Consideration is given to insulation for high voltage transmission lines of both the steel tower and wood pole types.

Based on this study, the following conclusions may be drawn:

1. The major factor of steel tower transmission line design is the shielding of the power conductors with properly located ground wires and maintaining the tower footing resistance as low as possible.

2. For towers of low footing resistance, on the order of 20 ohms, the wave is of short duration so that the minimum flashover voltage of the attached insulation corresponds to its breakdown voltage at 2 microsec. with a flat-topped wave.

3. In applying insulation to well protected high voltage lines, suspension insulators should be judged by their impulse flashover characteristics at 2 microsec.

4. The choice of insulation for lines not protected, or inadequately protected, by ground wires is based upon impulse flashover values at long time lags of the order of 10 to 50 microsec.

5. Impulse flashover space effectiveness of suspension insulators improves with increase in unit shell diameter at moderate spacings.

6. Impulse flashover space effectiveness for all unit diameters falls off with increase in unit spacing.

7. Flashover space effectiveness decreases with increase in string length.

8. The cost for a given impulse flashover voltage generally is lower for larger diameter units and higher for larger unit spacings.

9. Available service data and laboratory tests show that the 12-in. unit is as serviceable as a 10-in. unit. (A.I.E.E. Paper No. 32-61)

# Normal Frequency Arcover Values of Insulators as Affected by Size and Humidity

By H. A. Frey[13]
K. A. Hawley[13]

DATA covering the electrical characteristics of comparable insulators, as received from different sources, are frequently conflicting and a study has been made therefore to establish rules whereby such characteristics can be estimated with a reasonable degree of certainty from the dimensions of the insulators. A long series of carefully made tests are summarized in the accompanying table.

**Kilovolt Flashover Values Per Inches Arc Length**

| Insulator Type | Dry Value | Wet Value |
|---|---|---|
| Suspension<br>0 to 100 inches | | |
| Standard cemented | 10.5 to 9 | 7 to 6.8 |
| High strength cemented | 10.5 to 9 | 7 to 6.3 |
| Hewlett flat disk | 10.5 to 9 | 7.5 |
| Hewlett fish tail | 10.5 to 9 | 6.5 |
| Pin types | | |
| Small | 14 | 7 |
| Multipart | 14 to 11.4 | 8.9 |
| Apparatus insulators<br>(Dry 0 to 110 inches) | 11 to 7.3 | 8 to 5.7<br>(Erratic) |
| Equipment bushings | | |
| Solid type | 13.6 to 6.75 | 8.3 |
| (With bare conductor) | 12.4 to 6.1 | 8.3 |

Where two figures are given, the first applies to small insulators and the second to the larger insulators. In addition the ratio of wet flashover values in kilovolts to the wet striking distance in inches was found to be from 14 to 10.6 for high strength cemented suspension insulators, erratic for multipart insulators, and 13 to 10.4 for apparatus insulators. It was found that for dry arcovers the humidity correction per 0.1 in. mercury water vapor pressure was 2 per cent for standard cemented suspension insulators, apparatus insulators, and solid type equipment bushings; and 3 per cent for small, multipart, and pin type insulators. (A.I.E.E. Paper No. 32-62)

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[10] Ohio Insulator Co., Barberton, Ohio.

[11] Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

[12] Westinghouse Elec. & Mfg. Co., Derry, Pa.

[13] Locke Insulator Corp., Baltimore, Md.

# News
## Of Institute and Related Activities

# Winter Convention Success Due Largely to Committee Efforts

THE INSTITUTE'S winter conventon held in New York, N. Y., January 25-29, 1932, brought forth an official registration of 1,429 persons. This attendance was highly gratifying and definitely refuted the occasional predictions that attendance would be small. Of even more importance perhaps is the fact that interest exhibited in the technical sessions and other features of the convention was in line with the attendance. All in all the convention may be said to have been very successful.

### Opening of the Convention

The convention was officially opened at 2 p.m. January 25. Following introductory remarks by E. B. Meyer, chairman of the winter convention general committee, and W. H. Harrison, chairman of the technical program committee, the opening address was given by Dr. C. E. Skinner, president of the Institute. In his talk, presented elsewhere in this issue, Doctor Skinner outlined some of the activities and accomplishments of the Institute, and interestingly discussed the engineer as a citizen. At the conclusion of this speech, honorary membership in the Institute was conferred upon Dr. Frank J. Sprague, past-president of the Institute, and a pioneer in the development of electric traction. Doctor Skinner then stated that he had just received a letter from Sir Robert Hadfield, London, England, announcing a gift to the Institute of a bronze plaque commemorating the Faraday centennial. The meeting then was turned over to Mr. Harrison who formally opened the series of fourteen technical sessions. As abstracts of, or articles based upon, all 64 papers presented at these sessions already have been published (see Electrical Engineering for January 1932, p. 39-49, and for February 1932, p. 130-2), they will not be reviewed here. However, summaries of the discussions following presentation of some of these papers will be given in subsequent issues of Electrical Engineering.

One of the most impressive of the several interesting non-technical features of the convention was the joint medal presentation which took place on the evening of January 27. On this occasion the Edison Medal was presented to Dr. E. W. Rice, Jr., and the John Fritz Medal to Dr. M. I. Pupin. Many leaders in the engineering profession including several former Edison and John Fritz medalists were seated on the platform. These presentations, as well as the conferring of honorary membership upon Doctor Sprague, are reported elsewhere in this issue.

The success of the convention's annual buffet supper and smoker was repeated this year, on the evening of January 26, with an attendance of about 900. The committee responsible for this lively affair consisted of G. W. E. Draper, *chairman*, E. S. Banghart, W. G. Freeman, J. E. Goodale, R. A. McClenehan, L. K. Murphy, C. F. O'Neill, C. H. Sanderson, H. R. Searing, H. O. Siegmund, Morton Sultzer, and H. G. Wood. Following the buffet supper, an elaborate entertainment in the auditorium was provided by a capable master of ceremonies assisted by an excellent group of artists.

### Annual Dinner-Dance

The annual dinner-dance was held in the Grand Ballroom of the Hotel Astor on January 28, and proved to be well attended. This event was preceded by a reception in honor of Doctor Skinner. The receiving line, in addition to Doctor Skinner, included the three honorary members present, Dr. Ambrose Swasey, Dr. Chas. S. Scott, and Dr. Frank J. Sprague; E. B. Meyer, general convention chairman, and H. P. Charlesworth, vice-president of the Institute for the New York District. Responsible for the success of this occasion was the dinner-dance committee composed of E. J. Johnson, *chairman*, C. R. Beardsley, N. M. Garland, W. S. Hill, H. L. Huber, R. H. Hughes, J. F. Kelly, F. A. Muschenheim, R. F. Penman, C. S. Purnell, H. R. Searing, and D. M. Simmons.

Entertainment for the women was arranged by the ladies' committee with Mrs. E. B. Meyer as chairman, assisted by Mrs. O. H. Caldwell, Mrs. H. P. Charlesworth, Mrs. H. C. Dean, Mrs. W. H. Harrison, Mrs. F. L. Hutchinson, Mrs. C. R. Jones, Mrs. G. L. Knight, Mrs. R. L. McLellan, Mrs. W. R. Smith, Mrs. C. E. Stephens, and Mrs. R. H. Tapscott. Activities included the popular and well attended luncheon and bridge, many independent theater parties organized through committee assistance, and excursion trips particularly suited to the interests of the women. In arranging trips for both men and women, some noteworthy successes were scored by the inspection trips committee composed of W. R. Smith, *chairman*, I. S. Coggeshall, G. F. Fowler, Henry Kurz, H. C. Otten, R. D. Parker, V. A. Shields, H. P. Sleeper, and R. L. Webb. The most popular trip was that to the U.S. Naval air station at Lakehurst, N. J., where the U.S.S. "Akron" was inspected. The registered attendance for this trip was 379 persons. The next most popular visit was that to the studio of the Jenkins Television Corporation, attended by 141 persons, while the Empire State Building drew the third largest number with 67. A scenic trip up the Hudson River also was available, and in addition to specified trips to local points of engineering interest, opportunity was afforded the members and guests to select from a comprehensive list of plants which might be of particular interest to them. The registration for all inspection trips totaled 893.

Too much credit for the success of the entire convention cannot be given to the general convention committee and to the convention executive committee. The first of these, with E. B. Meyer as chairman, included O. H. Caldwell, H. P. Charlesworth, H. C. Dean, W. H. Harrison, C. R. Jones, G. L. Knight, C. E. Stephens, and R. H. Tapscott; while the executive committee consisted of C. E. Stephens, *chairman*, C. R. Jones, *vice-chairman*, G. W. E. Draper, E. J. Johnson, Mrs. E. B. Meyer, and W. R. Smith.

The officially registered attendance at the convention was 1,429 persons; attendance at the sessions indicated that others were present. The following tabulation reveals the distribution of those who were registered:

| District | Registrants |
|---|---|
| New York City and Foreign (3) | 898 |
| North Eastern (1) | 233 |
| Middle Eastern (2) | 214 |
| Great Lakes (5) | 34 |
| Canada (10) | 23 |
| Southern (4) | 13 |
| South West (7) | 12 |
| North Central (6) | 1 |
| North Western (9) | 1 |
| Total | 1,429 |

## President Skinner Urges Wider Engineering Effort

Dr. C. E. Skinner, president of the Institute, gave the address at the opening meeting of the 1932 winter convention, outlining some of the accomplishments of the Institute in the past, and pointing the way to future activities which might benefit electrical engineering as a profession and the nation as a whole. He also dwelt upon the responsibility of the engineer as a citizen, and urged greater activity in the affairs of the nation. Excerpts from Doctor Skinner's speech that relate to the more general aspects are given on p. 155 of this issue; those concerning Institute activities are quoted in the following paragraphs.

"The unusually fine program of papers before the 1932 winter convention is most satisfactory evidence that the American Institute of Electrical Engineers has been going forward during these years of depression. The winter convention, more than any other meeting of the Institute during the year, has come to be looked upon as the proper place and time to put into the record our outstanding accomplishments of the electrical industry for the year. The papers and discussions recorded at this and other meetings of the Institute constitute the history of the advances made in the electrical art in the United States, and to a considerable extent in the world. The application of electricity is without doubt the most important factor in the advance of our material civilization. It touches in some way almost every other factor which has a part in the advances which have been made during the last fifty years. Our Institute has a most enviable opportunity, supplying as it does the forum for the announcement of new discoveries, the record of achievements from year to year, and for discussion of the problems which the industry must face and find solution.

"During these last two years or more the Institute like governments, organizations, and individuals, has not been free from the effects of decreased income. This has but spurred us in an endeavor to give more service at less cost. It has been a challenge to greater efficiency in the conduct of our affairs. It has spurred us to provide, particularly in our publications, the best service to the members which can be given with the funds available. It has made necessary the limiting of the number and the length of papers presented, which is often a benefit rather than a detriment to their quality. It has spurred on the effort to carry the activities of the Institute more and more to the far flung Sections, and the eighteen or twenty Sections so far visited by your president have without exception indicated their enthusiasm and their unquestioned faith in the future of our great industry.

"This is no time to undertake expanded activities for the Institute, but it is not amiss to suggest new activities that may be planned now so as to be ready when funds will be available. It has seemed to your President that the time has arrived when an attempt should be made to write a comprehensive history of the Institute and of electrical engineering, particularly in regard to the formative years which were so fruitful of advances during the latter part of the last century. The curtain is going down for many of the players who took the chief parts in one of the greatest industrial dramas of history and much of the most interesting part of the story will be lost unless it can be written while some of these chief players are still with us. The writing of such a history would mean the collection of much data and a dramatizing and humanizing of the story as can be done by very few writers. It would seem that the American Institute of Electrical Engineers should be the body to arrange for the production of such a history if the funds could be made available and a qualified historian found.

"The Institute has been a pioneer in the standardization field, both national and international, and the recent reorganization of our standards work into the electrical standards committee should give great satisfaction to all our members interested in this subject. In the early years the standards committee of the Institute was undoubtedly the most logical and best possible means of carrying on this work, and in fact, the only place; but as the years went on, new organizations developed and new conditions arose which made it advisable to change our methods. The present plan recently adopted, largely formulated in its last stages by the late Dr. L. T. Robinson, promises to give us an entirely orderly and satisfactory procedure in the whole electrical standardization field, both national and international.

"The question of the licensing of engineers, bringing with it the necessity for a satisfactory definition of the term "engineer," and the establishment of standard qualifications by which we may be judged, has been brought about by licensing laws already passed in many States. It is of the utmost importance to all engineers that uniformity in these laws, definitions, and requirements, be established throughout the country.

"The members of the Institute, together with all other members of the engineering profession, may take some pride in the measures taken by our profession for the relief of the unemployed during this trying time of lowered industrial production. Through our local Sections, the cooperation of the groups being organized through the American Engineering Council, and through committees on unemployment, engineers as a group probably have done more for the relief of their fellow members than any other group or profession. Through our participation in the American Engineering Council we have joined in the organization of special committees in almost every State of the Union, and this action will do much to bring about greater solidarity in the engineering profession as a whole, even when this difficult time has passed. Our participation in the general work of the American Engineering Council and our joining with the plan of organizing state councils is bringing to us a greater appreciation of our responsibilities, not only as engineers but as citizens of the Republic. In times such as these, when every sort of scheme, sensible and fantastic, is before the national Congress, legislatures of the States, and even local governments, the calm considered judgment of the thinking citizen is required as never before. At this time there are before the Congress of the United States more than 12,000 bills calling for appropriations totaling approximately 30 billions of dollars, many of them with an engineering content. Another 12,000 bills are expected to be introduced before the session is over. As engineers and as citizens it is our duty as well as our privilege to take such part as we may through the American Engineering Council and its state councils, and by any other legitimate means, in giving advice as to which of these proposals are sound and which are unsound from the engineering point of view."

## Frank J. Sprague Made Honorary Member

As previously announced, (ELECTRICAL ENGINEERING Feb. 1932, p. 139-40) Dr. Frank J. Sprague, pioneer in electric traction, was elected an Honorary Member of the Institute at the meeting of the board of directors held December 4, 1931. The formal installation of Doctor Sprague as

Honorary Member was made on January 25, 1932, at the opening meeting of the Institute's winter convention. Dr. C. E. Skinner, president of the Institute, in making the installation pointed out that such membership is accorded only by unanimous vote of the board of directors and only to men of extraordinary prominence in the profession. In addition to Doctor Sprague the Institute Honorary Members now are: Andre E. Blondel, John J. Carty, Herbert Hoover, Guglielmo Marconi, Michael I. Pupin, Charles F. Scott, Motoji Shibusawa, Ambrose Swasey, and Elihu Thomson.

In Doctor Sprague's brief speech of acceptance, he addressed the audience as the apostles of speech, light, transportation, etc., so necessary to contemporary civilization. Modestly he stated that he was probably the oldest person in the room, and perhaps this tribute to him was because of his age, although he preferred to consider it to be otherwise, and to be to himself and his individual accomplishments rather than to his age.

# Edison Medal for 1931

## Presented to Dr. Edwin Wilbur Rice, Jr.

FOR "his contributions to the development of electrical systems and apparatus, and his encouragement of scientific research in industry," the Edison Medal for 1931, highest award of the A.I.E.E., has been presented to Dr. Edwin W. Rice, Jr. The presentation was made at a special session of the winter convention of the Institute, Wednesday evening, January 27, 1932. Doctor Rice is a Fellow and past-president of the Institute; he is one of the pioneers in electrical development in the United States, and has played a conspicuous part in the building up of the General Electric Company, of which he is now honorary chairman of the board. After appropriate remarks by Dr. C. E. Skinner, president of the A.I.E.E., the aims and purposes of the award were outlined briefly by Dr. D. C. Jackson, past-president of the Institute and chairman of the Edison Medal committee.

"Our Edison medalists," said Doctor Jackson, "are procreators of brilliant dyes which have worked miracles in coloring the raw fabric of civilization with the complexion of conveniences and comforts beyond the reach of kings in previous generations. These men are creators, picked and culled. . . .

"Last year, as chairman of the Edison Medal committee, I gave some history of the Edison Medal and referred to the men who joined in its founding in honor of Mr. Edison. Since then the great one whose name the medal bears has passed from his human affairs, but we shall continue to cherish his name through the years as we add to the honor roll of medalists.

"It is not altogether easy to discriminate discerningly between achievements. . . . John Ruskin once said that 'hundreds of people can talk for one who can think; but thousands can think for one who can see.' Each year, of the thousands who can think, one is to be found for the Edison medalist who also can see—one whose works prove that he can see and has seen some part of the invisible in our realm of electricity, and has brought it into full play for the glory of the culture and for the comfort of the civilized world.

**Dr. E. W. Rice, Jr.**

Recipient of the 1931 Edison Medal for "his contributions to the development of electrical systems and apparatus, and his encouragement of scientific research in industry"

"Such men are stirred by scientific curiosity and a strong discontent, a discontent even with what seems good if it may perchance be turned into better. It is the author of great works resulting from this glorious kind of discontent that we single out and acclaim on these occasions of conferring the Edison Medal. We of the American Institute of Electrical Engineers are under debt to the far-sighted founders of the medal for the privilege of administering their trust."

Following these remarks, Doctor Jackson read an address prepared by Dr. Elihu Thomson who, because of ill health, was unable to be present to speak in person. Doctor Thomson for many years has been Doctor Rice's close friend and associate; he was the man chosen to receive the first Edison Medal (1909) and was awarded the John Fritz Medal in 1916; he is an honorary member and past-president of the A.I.E.E. Excerpts from Doctor Thomson's address are given in the paragraphs which follow.

### Dr. Elihu Thomson
### Sketches Dr. Rice's Career

"It was while I was professor of chemistry and mechanics in the Boys' Central High School in Philadelphia, with Prof. Edwin J. Houston in charge of physics, that I first met Edwin Wilbur Rice as a pupil. . . . Rice entered the school in 1876 and graduated at the head of his class in 1880. What this meant in the training of a student may be illustrated thus: My class, known as the 55th, entered on examinations in 1866 about 170 strong, but of these only 18 graduated in 1870 at the completion of the four years' course. It was the same with the other classes, Rice graduating at the head of the 75th in like relation of numbers. Our relations began in the school work, in which I found him an earnest pupil, always wanting to learn, not only willing but eager to make all effort necessary for acquirement.

"When in 1880 I had decided to take up invention and electrical engineering work, Rice became a graduate, and . . . decided to associate himself with our new enterprise, practically as co-worker and assistant. With business associates, Houston and I had been carrying on work in Philadelphia. . . . On leaving Philadelphia for New Britain, Conn., where the American Electric Company had been organized to manufacture and exploit the Thomson-Houston system of arc lighting, Professor Houston's active connection with the enterprise ceased. This was in 1880, and to Rice and myself remained the task of nursing the new baby into vigorous life."

Doctor Thomson's address then outlined the difficulties experienced in the early history of this enterprise, during which time the Brush Electric Company of Cleveland, Ohio, acquired control of the American Electric Company, but later relinquished it to the "Lynn Syndicate." "I cannot say too much in praise of the invaluable assistance and perspicuous business acumen of Rice himself at this juncture," Doctor Thomson continued," for it was he who met the Lynn representatives and showed them the valuable points of the invention embodied in the Thomson-Houston system of arc lighting."

### FACTORY SUPERINTENDENT AT 22

Under the Lynn management a new and highly successful era began, and in November 1883 the manufacture was shifted to a new factory building in Lynn, Mass. Rice, then 22 years of age, was selected as plant superintendent at the new establishment.

"In his capacity of plant superintendent at Lynn (returning again to Doctor Thomson's address) an enormous amount of work fell to the lot of Rice, as the growth of the business extended into the a-c. field, incandescent lighting, and the electric railway; . . .

"It was during this period, and before the exodus which took many of our engineers from Lynn to Schenectady in 1892, as a consequence of the consolidation of the Edison General Electric with the Thomson-Houston interests under the presidency of C. A. Coffin, that our staff was enriched by the coming of the late Dr. Chas. P. Steinmetz to Lynn. . . . Rice had a leading part in securing the services of Steinmetz as a member of our technical and calculating staff at Lynn, leaving for Schenectady in 1892, or shortly thereafter. It was at this time that Rice was made technical director of the General Electric Company, a position held by him for many years, until promoted to the presidency, succeeding Mr. Coffin.

### FOUNDS RESEARCH LABORATORY

"In his position as technical director of the company, his work extended not only through the departments at Schenectady, but covered the undertakings of the several other works. . . . The responsibility was great and increasing. It was during the period of his earlier years at Schenectady that the idea of a works research laboratory was entertained. I remember receiving a letter from Rice asking my opinion of the project and requesting a statement of some of the problems which it might take in hand. In reply I pointed out the vast field covered by our ignorance, the possible solution of problems by research, and endorsed the project warmly as likely to be a great element in future technical advance.

"Thus, under Doctor Rice, the great research laboratory at Schenectady was put into action, with Doctor Whitney at the head, and such co-workers as Dr. Irving Langmuir, Dr. W. D. Coolidge, and many others, contributing through the years to its output.

"There is no space to enter into any of the details of the researches in science and technology which have been the outcome. To see a complete revolution in the field of lighting alone, we have only to point to the modern incandescent lamp with its filament of tungsten wire made by the Coolidge process and to the studies of Doctor Langmuir on the gases present in the lamp bulb. . . . The part that Doctor Rice had in this can be estimated only by such knowledge as those close to the evolutionary scene were enabled to obtain . . .

### MANY PATENTS RECEIVED

"Naturally, one so busy with electrical engineering advances has received a large number of patents in the United States. These number about 115, taken out individually or jointly with others. None the less, Doctor Rice arranged the atmosphere, so to speak, in which others could do their best work, and introduced into the organization of the industry methods which not only have benefited the company itself, but have added materially to the welfare of the employees.

"Doctor Rice's long career of attainment and usefulness naturally has brought to him many recognitions in the form of medals, honorary degrees, and decorations, both here and abroad. Doctor Rice is, I think, richly entitled to the bestowal of the Edison Medal, an honor which had Edison himself lived to know of it, would have met with his warm approval. Edison on several occasions expressed his high regard for Doctor Rice's personality and versatile ability as inventor, manufacturer, business man and financier. I think I can say for the surviving recipients of Edison medals that we are glad to endorse the action of the Edison Medal committee of the Institute in making choice of Dr. Edwin Wilbur Rice for the award on this occasion."

Presentation of the medal to Doctor Rice by President Skinner followed, after which Doctor Rice responded.

## Doctor Rice's Response Outlines Electrical History

"It is with profound pleasure," began Doctor Rice, "that I accept the Edison Medal, which I regard as the greatest of all prizes to be won by an electrical engineer. I shall treasure the medal itself as visible evidence that my work has met with the signal approval of my fellow engineers, and because of the precious memories recalled by the name and image which it carries.

"I am the first to receive this award since the death of the great man in whose honor it was established and whose name it bears; and I like to think that he would have regarded me as a worthy recipient. Among the most happy memories of my life are those of the days, all too few, which I was privileged to spend with Mr. Edison."

Doctor Rice then outlined the important developments in the field of electricity and electrical apparatus and equipment which he had observed throughout his career. These reminiscences began with his sight of a dazzling light (the arc light) at the Centennial Exposition in Philadelphia in 1876, which Doctor Rice stated was his earliest memory of anything electrical. He related seeing at the same exposition two Gramme machines, one being operated as a generator, and one as a motor. Speaking of the telephone Doctor Rice declared, "I shall never forget the thrill of my first message over the telephone. . . . I have never lost the sense of awe and wonder, that so simple a device is able to transmit and reproduce all the complex sounds, including human speech."

Doctor Rice also touched upon important inventions made by his contemporaries, including the invention of the incandescent electric lamp by Edison, Edison's experiments in the central station field, and his subsequent establishment of the first central generating station in New York. Later came the introduction of the single-phase a-c. system by William Stanley, and still later the multiphase a-c. system which at present is in almost universal use.

### EARLY ELECTRIC SYSTEMS

Speaking of some of the earlier systems which marked the development of electrical power networks Doctor Rice remarked that "all these systems were commercially successful; they grew rapidly, but were highly individualistic, even antagonistic, and were limited to their respective fields." Parallel with developments in the electric power supply and central station fields, Doctor Rice mentioned Sprague's and Van Depoele's electric trolley systems, as being really the foundation for modern electric transportation systems.

### WHAT OF THE FUTURE?

Departing from the past and present remarkable developments in the electrical art, Doctor Rice next had something to say about what might be expected of the future: "We of the engineering fraternity naturally think of the recent period as the electrical age," he said. "But these electrical and mechanical discoveries and inventions are not all. Similar progress has been made in chemistry, in biology, in astronomy, and in many other directions. . . .

"Why this sudden outburst of scientific achievement, so broad and general that our times may be aptly termed 'The Age of Applied Science?' The reason is clear: Men have found a way successfully to interrogate nature, to discover her secrets, to learn her laws, and then to put this information to practical use. Scientific research is the common name for this new tool. . . .

"No one knows the correct answer to the question as to whether or not we have reached the end of our material progress; but in view of the short time that man has used this new intellectual tool, and, moreover, when one considers the immensity and complexity of nature, it is reasonable to believe that if the same methods continue to be employed, progress also will be continuous.

"Therefore no limit is in sight, provided, and this is an important proviso, that man himself does not call a halt. The forces of ignorance, tradition, and superstition are strong and view with some alarm the progress of science. There are many who say that these new methods have been too successful, especially as applied to the field of production, and point to our great surplus of material things, to the increase in 'technological unemployment,' and all the tragic circumstances of our present depression including the paradox of poverty in the midst of plenty.

"The engineer refuses to believe that the world's troubles can be laid at his door. He places most of the blame upon the waste and extravagances of war and misdirected economic effort, to the stimulation of high pressure sales methods, the over-pledging of future wages and income, and reckless speculation in inflated values.

### Scientific Methods Must Be Continued

"While it may be admitted that there is no universal panacea and no *get well quick* cure, it would seem reasonable to expect real improvement if, for example, the same scientific methods which have been so effective in increasing production, could be brought to bear upon the problem of control and of balancing production against ultimate consumer demands. No claim is made that scientific men or engineers have a monopoly of wisdom or of brains; but it would seem that the methods which have proved so successful might be applied to the solution of the more complex social problems to the great advantage of all the people. Therefore instead of yielding to the forces of reaction, it is our duty to make strenuous effort to extend the use of the scientific method. This can be done only by education.

"Every man and woman should have the benefit of an education in the fundamental facts and methods of science. Every professional man should learn enough to understand something of the physical nature of the world, as well as of his own body. Science, in addition to creating all these new arts and new knowledge, may be accredited with something finer and more important. It has encouraged in the minds of its followers what may be called the scientific point of view.

"One who possesses this scientific point of view is inclined to be modest and tolerant of others; he searches for the truth; he hunts for facts which, if found, become his guide. He tries to see things as they exist, not as he has wished them to be; naturally he is honest with others but even more important, he is honest with himself in thought and in action. It is vitally important for our future welfare that our lawyers secure an education in science at least equal to their legal training. I single out the legal profession because the lawyer is today our political master. . . . If our legal doctors who make and interpret our laws remain ignorant of the new heaven and the new earth, what will happen to the poor bewildered common citizen.

"However, I think we may face the future with courage, as the expansion of educational facilities in recent years has been accompanied by an increase in the study of science in our schools and colleges. This may enable the new generation to meet the new problems with intelligence and success. After all, the forces of reaction and ignorance cannot prevail permanently in a country in which the voters are properly educated."

## Dr. Michael I. Pupin Receives 1932 John Fritz Medal

FOLLOWING Edison Medal presentation Wednesday evening, January 27, 1932, the 1932 John Fritz Medal was presented to Dr. Michael Idvorsky Pupin, "scientist, engineer, author, inventor of the tuning of oscillating circuits and the loading of telephone circuits by inductance coils." Doctor Pupin is an honorary member and past-president of the A.I.E.E., and was the recipient of the Edison Medal in 1920.

The John Fritz Medal is an honor awarded by sixteen representatives of the four national engineering societies: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, and American Institute of Electrical Engineers. It was established in memory of John Fritz of Bethlehem, Pa., one of America's great pioneers in the iron and steel industries. The medal is of gold and is awarded not oftener than once a year for "notable scientific or industrial achievement, without restriction on account of nationality or sex."

This portion of the Wednesday night session was presided over by William S. Lee, junior past-president of the A.I.E.E. as chairman of the John Fritz Medal board of award. Mr. Lee introduced as the next speaker Bancroft Gherardi, past-president of the A.I.E.E. and vice-president and chief engineer of the American Telephone and Telegraph Company. Mr. Gherardi spoke at some length regarding the life and achievements of Doctor Pupin; his address follows.

### Mr. Gherardi Outlines Doctor Pupin's Achievements

"Fifty-eight years ago, late in the winter of 1874, a young Serbian landed at Castle Garden. He was without money or property, without friends or influence, and without knowledge of the language of this country. Many would say that he had nothing; but this would fail to recognize the things which he had. He had good health, character, ambition, a mind eager to find knowledge and to use it, and high ideals. This evening I have been selected as the spokesman of four great engineering societies whose representatives are gathered here to pay a tribute of esteem and affection to him.

"Limitations of time compel silence upon Doctor Pupin's early struggle for an education, and his studies at Columbia University, at Cambridge (England) and at the University of Berlin; except only this: that no one can read the account which he gives of this period of his life in his wonderful autobiography without being convinced that in the earlier influence of his mother, and in the period in which he was getting his education, was laid the foundation upon which rest his many achievements during a long and varied career. From the time of his connection with the staff of Columbia University, the story of his life is a continuous record of contribution to our knowledge and our methods of thought. Of these only a few high spots can be mentioned this evening.

### Invention of Loaded Telephone Line Well Timed

"Perhaps because I am a telephone engineer, I am starting by referring to his invention of the loaded telephone line. For several years prior to Doctor Pupin's work which led to his inventions and patents on this subject, it was known that the addition of continuously distributed inductance to a telephone circuit would add to the transmission efficiency of the circuit; that is to say, it would diminish the losses of the telephone current during its passage through the wires. It had been suggested that similar results should follow from the placing of inductance coils at intervals in the circuit. This had even been tried experimentally without favorable results. By means of a beautiful mathematical investigation Doctor Pupin established the fact that it was not sufficient to place inductance at intervals in the circuit, but that the inductance must be designed with reference to the circuit conditions and must be uniformly spaced at intervals having a relationship to the shortest waves which it was desired to transmit. He confirmed the results of his mathematical investigations through a brilliant series of laboratory experiments and in addition he designed and demonstrated the advantages of the toroidal type of loading coil—a design which fundamentally has persisted even to the present time, although it dates from over thirty years ago.

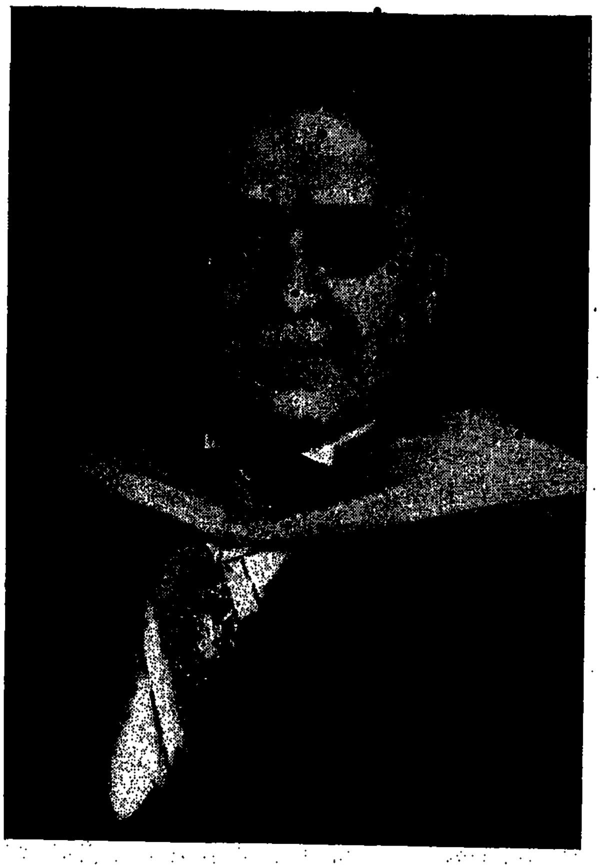
"Doctor Pupin's patents were acquired by the Bell Telephone System and from that day to this his inventions have played a fundamental part in long-distance telephony. The time at which Doctor Pupin made these inventions was most opportune: They came just when telephone engineers were confronted with serious problems in the extension of long distance telephone service over greater and greater distances, and also when, due to the unfavorable effects of non-loaded telephone cables, very serious problems were arising in the planning of long distance lines. These problems were particularly difficult where the numbers of circuits required were so great that overhead open wire constructions presented formidable difficulties, and where the lines had to be brought into large cities.

"As part of the mathematical investigation of the loading problem, Doctor Pupin developed a mathematical theory of certain forms of artificial lines or electrical networks. Such artificial lines today have numerous important applications in the communication art.

### Originated Tuned Circuit

"Doctor Pupin was the original discoverer of the electrically tuned circuit, that is, of the possibility of so proportioning the electrical characteristics of a circuit that it would respond energetically to any predetermined a-c. frequency. The electrically tuned circuit is used today in every important branch of the electrical art, in telephony, in telegraphy, in power transmission, and last but not least, in radio systems. It was first used by him and then by others in the analyzing of alternating currents, that is to say, in their separation into the different frequencies of which they were composed. In a way Doctor Pupin was unfortunate in the time in which he made this invention. At the time that he made the invention, the radio art was practically non-existent and for many years thereafter it was used only for incidental and specialized purposes. Today, however, practically every home contains an electrically tuned circuit in the radio receiving set; but Doctor Pupin's discovery was so far ahead of the development of radio and therefore of the general use of tuned circuits that few realize that, if this contribution of his were to be removed from the radio systems of the present day, they would no longer function.

"Immediately upon the discovery of the X-ray, Doctor Pupin made two important contributions. He was the first to discover the phenomenon of secondary X-ray radiation; that is, that when X-rays strike on any matter, that matter becomes itself a source of X-ray radiation. This fact was not only important in itself, but it contributed to many other scientific advances in X-ray work. Doctor Pupin did much experimental work in X-ray photography and he was, I believe, the first in this country to make an X-ray picture with the aid of a fluorescent screen. The advantage of this method over those previously used was that it enormously shortened the time necessary for the photographic exposure and made it possible to take X-ray pictures in many medical and surgical cases where, without a short exposure it would not be practicable to get an effective X-ray picture.



**Dr. M. I. Pupin**

John Fritz Medalist for 1932 with the citation of "scientist, engineer, author, inventor of the tuning of oscillating circuits and the loading of telephone circuits by inductance coils"

"Doctor Pupin was the first to suggest the use of an electrical rectifier in connection with the receiving of radio signals. While his original invention made use of an electrolytic type of rectifier cell, his invention was broad enough to cover the use of any type of rectifier element. Here again Doctor Pupin was unfortunate in that his invention was so far ahead of the development of the radio art that it was many years after his work was done before there was any extensive opportunity to use this contribution practically.

### An Educator as Well as a Scientist

"Doctor Pupin has had an important part in the building up of the scientific and engineering departments of one of our greatest educational institutions—Columbia University. He has not only contributed much in this way, but the graduates of Columbia who studied under him in many cases have made distinguished records in the fields of science and engineering. Of the many, I shall only mention two—Dr. Robert A. Millikan and Dr. Gano Dunn, a past-president of the A.I.E.E. These and many others testify with the greatest enthusiasm to what they owe to Doctor Pupin's teaching and to his inspiration.

"During the war, Doctor Pupin had an important part in starting the National Research Council. The purpose of this body as defined by President Wilson in his executive order with reference to it was: stimulating research in mathematical, physical, and biological sciences, and in the application of these sciences to engineering, agriculture, medicine, and other useful arts, with the object of increasing knowledge, of strengthening the national defense, and of contributing in other ways to the public welfare. Throughout the period of our participation in the war, Doctor Pupin devoted his abilities and his boundless energy to the vital problem of submarine detection.

### "From Immigrant to Inventor"

"No statement of Doctor Pupin's achievements, however brief, could omit the mention of his autobiography, 'From Immigrant to Inventor.' It is in itself a contribution to literature, to science, and to education, and a wonderful study in the process of Americanization. From this book many native-born Americans can learn something of the spirit and aims of our country.

"Doctor Pupin's honorary degrees, his membership in societies and his presidencies of them, his American and foreign decorations, medals and awards, are too numerous to mention; but they testify to the judgment of others as to his personality and his work. In 1921 the A.I.E.E. awarded to him the Edison Medal, the highest honor which the Institute could confer. Now three other great engineering societies, civil, mechanical, and mining, have joined with the electrical engineers in awarding to him their great joint honor.

"Doctor Pupin, I salute you: an inventor who has made important contributions to the application of electromagnetism to the uses of man; a scientist who has added important facts to our knowledge of science and contributed to scientific idealism; an educator who not only has an enviable record as to those who have studied under him, but who has advanced the cause of education; a citizen who has contributed much to this country; an American who is proud of the country of his adoption, and of whom his country is proud."

Following Mr. Gherardi's address, Mr. Lee presented the medal and certificate to Doctor Pupin with fitting remarks, to which Doctor Pupin responded as follows:

### Doctor Pupin Responds

"As I sat here," began Doctor Pupin "listening to the kind eulogy, the generous eulogy of my good friend, Bancroft Gherardi, I could not help recalling to memory some of the faces of the peasants in my native village who were my schoolmates over 65 years ago. I saw them as if in a vision, sitting right here in the front row, looking around, dazed, wondering. One of them asked me, 'Michael, how in the world did you manage it? How many saints and angels, tell us, guided you on your way from the humble pasture lands of our little village to this glorious palace of American engineers?'

"To them I answer, 'Some day I will send you a translation of the beautiful speech of Bancroft Gherardi, which will answer the question better than I can.' . . . At every point of my uphill road, I met generous encouragement. Among these, I must mention the generous encouragement of my Alma Mater, Columbia College. Without its scholarships, fellowships and facilities for scientific research work, I should have been unable to contribute even the little I have contributed in the scientific field. In fact, I wouldn't be here this evening.

"Their generous spirit is the same as the generous spirit of the John Fritz Medal board which conferred upon me this very distinguished honor. I accept it; I accept it gladly. I am proud of it and I promise that I shall always consider it as a token of the generous spirit which I met at every step in this blessed land.

"Now, my friends, permit me to change my line of thought. I have been requested to address you and deliver to you, if possible, a message from the field in which I toil as an humble worker. That field is the field of power, of heat and electrical power."

[The remainder of Doctor Pupin's address may be found on p. 156-7 of this issue.]

## Fourteen Institute Committees Hold Meetings During Winter Convention

DURING the 1932 winter convention in New York, N. Y., January 25-29, meetings were held by several of the Institute's general and technical committees. Proceedings of these meetings are summarized in the following paragraphs, except the standards committee meeting which is reported under the "Standards" department of this issue.

### STUDENT BRANCHES

Previously, this committee had been authorized to get out a booklet telling what the electrical engineer is, what he does, what type of man makes the best engineer, what qualities he should have, and what education he should be given. This was prepared with the object of giving high school students some definite information concerning electrical engineering in order to discourage those who should not go into it, and to encourage those who should. Following the distribution of two copies of this booklet to each of a selected list of 1,500 of the leading high schools in the country, requests for 12,000 copies were received, 2,000 more than the original edition.

Because of the widespread and enthusiastic approval which this booklet met, the committee at its meeting voted unanimously to ask the board of directors to authorize the printing of an additional 20,000. (The board of directors later authorized the printing of 10,000 additional copies at present.)

The second of the two most important problems discussed at this meeting was that of arranging attractive programs for the student Branches, on the subject of safety. A bibliography to be prepared by the committee and a paper by Prof. C. F. Scott on this subject, are expected to be sent to all Branches. It was proposed that one type of meeting might consist of a paper by a student on "What Safety Means in Industry," accompanied by a demonstration of the prone pressure method of resuscitation from electric shock. It was voted that the committee arrange definite plans for conducting safety instruction through the student Branches.

### TECHNICAL PROGRAM

Plans for the summer convention program were discussed by the technical program committee, and it was decided to include a session on protective devices in place of a session on application to iron and steel production, due to a conflict in date with the national convention of the Association of Iron and Steel Electrical Engineers. Also it was decided to add sessions on power generation, and on electrochemistry and electrometallurgy. The sessions which it is now planned to hold during the summer convention are: transmission and distribution, communication, automatic stations, electrical machinery, research, education, protective devices, power generation, electrochemistry and electrometallurgy, and selected subjects.

In connection with the number of pages available for printing, a discussion took place on the value of printing the technical committee reports submitted yearly by the various technical committees. It was decided that the question as to whether or not committee reports should be published, would be left to the discretion of the technical committee chairmen.

It was believed that section 89 of the by laws requiring that manuscripts of papers to be presented be received not less than ninety days before the date of presentation should be enforced, and therefore it was voted that "the manuscripts tentatively scheduled for the summer convention must be received at Institute headquarters, in complete form, by March 20, 1932, and where papers are not received those available on the docket will be substituted."

### AUTOMATIC STATIONS

The automatic stations committee decided to request allotment to this committee of one session at the coming summer convention. Among the papers available are two on operating data and experiences with automatics, and two describing new devices.

It was decided to give further consideration to revisions of standard designations. A discussion was held concerning the various automatic schemes used with communicating circuits such as supervisory control and remote indication. A subcommittee was appointed to correlate these schemes with the various forms of communicating circuits available. In considering reclosing cycles on a-c. automatic reclosing circuit breakers, it was decided to investigate the present tendency to use only one or two reclosures instead of the usual three, and the use of practically instantaneous operation on the first reclosure.

### EDUCATION

At the meeting of the committee on education, an attempt was made to determine the proper sphere of activity and responsibility of this committee. Without much guiding precedent this was a rather complicated matter, but the following five lines of activity were adopted.

Post-college education is to be encouraged at all Sections where there may seem to be need for such work. It is contemplated that the plan of post-college education proposed by Prof. Edward Bennett in 1929, and which has met with such gratifying success in the Chicago Section, be used.

Educational work for unemployed engineers is to be promoted wherever possible, in line with the plan employed at Columbia University, Ohio State University, and Massachusetts Institute of Technology, where unemployed engineers may sit in lecture courses without charge and without credit. It also was decided to urge the board of directors to encourage the work of the committee on student branches in supplying to high school students reliable information regarding engineering. The committee endorsed the work being done by the Society for the Promotion of Engineering Education in connection with summer schools for engineering teachers. The session on education to be presented at the summer convention also was discussed.

### ELECTRICAL MACHINERY

Three major items were considered at the meeting of the electrical machinery committee. A request from the standards committee, to proceed with the preparation of test codes on other apparatus similar to the transformer test code previously prepared by the transformer subcommittee, was considered. Because the purpose of this test code is to enable operators and others not familiar with electrical design to carry out tests on electrical machines, the subcommittees on synchronous, induction, and d-c. machines were asked to prepare test codes in their respective fields. These will supplement present standards.

Technical programs for the Providence meeting and the Cleveland convention were discussed, and plans were made for one session on electrical machinery at each.

The practise of surge voltage testing of transformers is now general, but because of the many difficulties in specifying test conditions and requirements to be fulfilled no standards have been prepared on this subject. It was the opinion of the committee that the formulation of such standards should now be attempted, and the transformer subcommittee therefore is planning to undertake this work in the immediate future.

### ELECTROCHEMISTRY AND ELECTROMETALLURGY

At the meeting of the committee on electrochemistry and electrometallurgy, papers for presentation at the summer convention were considered and suggestions offered both as to the papers to be presented and the material which might advisably be included in them.

The desirability was considered of securing the cooperation of the Institute in plans now in process of formation by the American Electrochemical Society for a Faraday centennial ceremony to be held during the World's Fair in Chicago in 1933. The organization of the membership along more effective lines also was considered, and it was decided to obtain the written comments of each member before submitting recommendations to the directors.

### ELECTROPHYSICS

Three matters were taken up at the meeting of the committee on electrophysics. First, there was a discussion of the general matter of the definition of electric and magnetic units, and of systems of units. The electrophysics committee has taken no formal action in this matter, of course, but has sent a communication to the standards committee. At the present time there is much active work under way on this subject on various organizations. Second, the general manner of reviewing of papers was discussed. Third, the committee discussed the general subject of the extent to which papers on electrophysics are being secured prompt and effective publication in the A.I.E.E. publications.

### INSTRUMENTS AND MEASUREMENTS

At the meeting of the committee on instruments and measurements, the activities of the subcommittees were reported and record made of the fact that the subcommittee on recording-instrument standards had completed its work. These standards were submitted to the standards committee for adoption. Similar action also had been taken in the case of the standard set of definitions dealing with telemetering.

A previously arranged joint meeting with the subcommittee on definitions for instruments and testing also was held. A considerable part of this meeting was concerned with a discussion of proposed changes in these definitions, and the authorization of a special subcommittee to act for the instruments and measurement committee so that the work on definitions of instruments and testing could be concluded as speedily as possible.

### POWER GENERATION

The committee on power generation received the reports of several subcommittees, and discussed plans under way for the preparation of papers for presentation at the coming summer convention. The recent notable progress in the use of high temperature and high pressure steam was reviewed and a paper now being prepared was discussed with special reference to modern methods of fabrication in which electricity played an important part. Power system interconnection was discussed, and it was pointed out that the main dearth of information now lies in papers describing the actual operating experience of large interconnected systems. Other papers also now are under preparation on the subjects of recent trends in power plant design and hydroelectric development. Further, a symposium is being prepared on the features of power station and system operation that contribute to the economy and reliability in the service rendered by several power systems.

Methods for securing continuity in the work of the committee were discussed, and for this purpose the drafting of an interim progress report for 1932, rather than the customary complete survey of current progress in power generation normally made at intervals of two years, was considered.

### POWER TRANSMISSION AND DISTRIBUTION

Reports from the various subcommittees were received first at the meeting of the power transmission and distribution committee. The present set-up of subcommittees was approved. The sessions to be held and papers to be presented at the next few meetings and conventions of the Institute were discussed, and papers for several of these definitely selected. For the summer convention the question was raised as to whether the session should be devoted to papers on lightning, or to papers on mechanical features of transmission systems, particularly conductor vibration. Since several sessions have been devoted to lightning during the past few years, while the mechanical features have been neglected, it was decided to devote the session to conductor vibration.

A general report on transmission and distribution in the United States is being prepared by members of this committee, for presentation at the International Electrical Congress in Paris, France, this summer, and it was brought out that this is to be a comprehensive report and should be of considerable reference value.

### TRANSPORTATION

A list of papers proposed for future technical sessions was discussed at some length during the meeting of the transportation committee. Following that, the chief discussion centered on the question of requirements for motive power. It was agreed that this is a most important subject, and one which had been touched upon very slightly in Institute meetings. It was suggested also that the subject be broadened to include track maintenance as a function of axle loadings and other features, and to include design of motive power. A suggestion was made that the subject might be developed by means of a questionnaire, possibly in cooperation with the engineering division of the American Electric Railway Association.

### Transmission Towers and Conductors

An independent meeting of the subcommittee on steel transmission towers and conductors was held, taking the form of an annual gathering in which reports from different groups in the subcommittee were read. Some of the recent developments in theory and practise in connection with transmission towers and conductors were discussed, including the possibilities of covering these subjects in technical papers. Some of these subjects, although not actively followed by the subcommittee, have been checked from time to time to see that they get their due publicity, it being the aim of this subcommittee to foster as far as possible the writing and presentation of papers dealing with subjects that are of present day interest.

Among the subjects discussed were the development of hinged crossarms on steel towers, the investigation of embrittlement of hot-dipped galvanized steel, a new straight-line column formula, and a proposal for the drafting of requirements for modern steel tower lines as regards clearances and electrical characteristics The present status of studies of vibration of electrical conductors was reviewed.

### Lightning and Insulators

At the meeting of the lightning and insulator subcommittee of the power transmission and distribution committee, the three preferred impulse test waves (½×5, 1×10, and 1½×40 microsec.), previously adopted by the committee, were discussed and the following agreements reached.

1. These three waves are to be recommended for use in securing impulse data on insulators and insulation.
2. These waves could be secured without difficulty in any recognized laboratory today.
3. It was advisable for the laboratory making impulse tests to check the impulse wave obtained from the oscillograph with the calculated wave.
4. In all cases, impulse data given out to the engineering field should be accompanied by a record of the actual wave used in test.

It is believed that the above procedure will greatly clarify the present situation and enable those who use impulse data to obtain similar information from all manufacturers and compare and use it on an intelligent basis. The committee plans to put complete recommendations on preferred impulse test waves, general methods of tests, etc., in the form of a paper for presentation in the near future.

Past discrepancies in 60-cycle flashover of insulators were found to be due to different humidities at the time of tests. Correction for this feature brings flashover values within reasonable agreement.

The desirability of using the same impulse wave for insulation testing as for lightning arrester testing is recognized; but since the test conditions on arresters are inherently different from those on insulation, it was agreed that no logical basis for using the same impulse waves for both types of test exists.

It was agreed that the impulse characteristics of protective or coordinating gaps, should be obtained; and it was believed that this information would become available when similar information on bushings is obtained and made public.

The beneficial effects indicated by the use of the so-called counterpoise in reducing lightning troubles on transmission lines were discussed. The limited number of such installations is being closely followed, but further experience is necessary before final conclusions are made.

## Great Lakes District Meeting

Arrangements essentially have been completed by the local committee for the three-day meeting of the A.I.E.E. Great Lakes District to be held at Milwaukee, Wis., March 14-16, 1932, with headquarters in The New Pfister Hotel. A tentative technical program and information about hotel rates were published in Electrical Engineering, February 1932, p. 133. The few minor changes in the tentative technical program made since the first announcement are outlined in the following paragraph.

"Normal Frequency Arcover Values As Affected by Size and Humidity" by H. A. Frey and K. A. Hawley, Locke Insulator Corporation, has been added to the Wednesday morning session. The paper on "Factors Affecting Sparkover of Insulators and Bushings" by W. L. Lloyd, General Electric Company, formerly scheduled in the Tuesday morning session, has been transferred to the Wednesday morning session to bring together all of the papers on insulator sparkover. To make room for these and keep the number of papers per session nearly uniform, the two papers on mercury arc rectifiers were transferred to the Tuesday morning session.

A student session also will be held on Monday at 2 p.m. and selected papers will be presented by students of the Great Lakes District.

## Research Assistantships Offered by U. of Illinois

To assist in the conduct of engineering research and to extend and strengthen the field of its graduate work in engineering, the University of Illinois maintains fourteen research graduate assistantships in its engineering experiment station. Two other such assistantships have been established under the patronage of the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of $600 and freedom from all fees except the matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry.

Appointments are made and must be accepted for two consecutive collegiate years of ten months each, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Half of the time of a research graduate assistant (approximately 900 clock hours for each ten-month period) is required in connection with the work of the department to which he is assigned.

Nominations to these positions, accompanied by assignments to special departments of the engineering experiment station, are made from applications received by the director of the station each year not later than the first day of April. Preference is given those applicants who have had some practical engineering experience following the completion of undergraduate work. Appointments are made in the spring, and become effective the first day of the following September. Research work and graduate study may be undertaken in architecture, architectural engineering, ceramic engineering, chemistry, civil engineering, electrical engineering, mechanical engineering, mining engineering, municipal and sanitary engineering, physics, railway engineering, and theoretical and applied mechanics. Additional information may be obtained by addressing The Director, Engineering Experiment Station, University of Illinois, Urbana, Illinois.

**Illuminating Engineers Convention Announced.**—The twenty-sixth annual convention of the Illuminating Engineering Society has been announced for the week of September 26, 1932, and is to be held at the New Ocean House, Swampscott, Mass. Officers of the society are; *president*, J. Daniels, Boston, Mass.; *vice-presidents*: J. W. Barker (F'30) New York, N. Y. and J. L. Stair, Chicago, Ill.; *general secretary*: E. H. Hobbie, New York, N. Y.; and *treasurer*, A. L. Powell, New York, N. Y.

# F. L. Hutchinson Succumbs to Heart Failure

AN UNTIMELY END came to a noble career when death stilled the courageous, fighting heart of F. L. Hutchinson, well beloved national secretary of the Institute, at 12:30 a.m., Feb. 26, 1932. Literally a martyr to the cause of his chosen life work, Mr. Hutchinson gave to Institute problems so generously of his indefatigable energies that he was unable to withstand the attack of heart trouble which finally took its fatal toll. The membership of the Institute has lost a leader militant in the defense of its best interests; the officers an able and willing team mate; the staff a kindly, keenly alert, inspiring taskmaster; and his family a devoted companion.

### EARLY EXPERIENCE

Frederick Lane Hutchinson was born in Elizabeth, N. J., April 2, 1866. He began his business experience in the service of the Pennsylvania Railroad Company in one of its principal offices in New York City, where he had several years' experience in accounts, correspondence, and general office work. In 1889 he entered Cornell University and was graduated from the electrical engineering course in 1893, when he entered the employ of the Westinghouse Electric and Manufacturing Company. After several years' experience in the manufacturing, testing, engineering, and sales departments in Newark, N. J., New York City, and Pittsburgh, Pa., he was transferred to the publication department, where for several years he was employed in preparing the technical literature of the Westinghouse company.

In 1901 he became manager of the publication department of the C. W. Hunt Company, New York, and in the following year became advertising manager of the National Electric Company of Milwaukee, Wis. A year later he was made manager of electrical sales for the same company.

### A.I.E.E. WORK

In 1904 Mr. Hutchinson returned to New York and undertook some special work on the Transactions of the American Institute of Electrical Engineers. Gradually the scope of his work was increased until, in February 1908, upon recommendation of Secretary Ralph W. Pope, he was appointed assistant secretary. Upon Secretary Pope's resignation after 27 years of service with the Institute, Mr. Hutchinson was, in August 1911, appointed acting secretary by the board of directors. On January 12, 1912, the board of directors of the Institute unanimously appointed him national secretary, upon the unanimous recommendation of the Institute's secretary committee.

FREDERICK LANE HUTCHINSON
1866-1932

Mr. Hutchinson became an Associate of the Institute in 1894 and was transferred to the grade of Member in 1913. He was thoroughly familiar with the history and policies of the Institute, the scope and duties of its numerous committees and representatives, and the relations of the Institute to other engineering and similar organizations, both in this country and abroad. He was one of the delegates of the Institute to the World Power Conference, London, 1924, and to the World Engineering Congress, Tokyo, 1929. He served as a member of various Institute committees, both before and after he became secretary. Immediately prior to his death he was a member of committees having supervision of several important activities, including publications, coordination of Institute activities, award of Edison Medal, and maintenance of Institute headquarters. Mr. Hutchinson also was a representative of the Institute on the Assembly of American Engineering Council, the division of engineering and industrial research of the National Research Council, and on the Engineering Societies Library Board. He was an enthusiastic worker for the development of the engineer and for the enhancement of the engineering profession, and was identified with various joint endeavors of the national engineering societies and allied organizations the efforts of which were directed toward that end.

### INSTITUTE GREW RAPIDLY

His long experience as assistant secretary particularly qualified him for the duties of secretary. At the time of his appointment the Institute had little more than one-third of its present membership, and its rapid growth and increasing activities made growing demands upon the secretary's office, in meeting which Mr. Hutchinson displayed marked executive ability. He combined a very pleasing personality with a highly judicial temperament. With characteristic energy he mastered every phase of the Institute's activities, and the directors and governing committees of the Institute came to defer more and more to his judgment in all matters of Institute management. To every suggestion for the improvement of the Institute or changes in its policy he accorded a careful and impartial consideration, and the fairness of his decisions gained the respect and confidence of all with whom he dealt.

As the work of the Institute increased, Mr. Hutchinson gradually built up a small staff of assistants to whom he was the guide and inspiration. He inaugurated a series of monthly office conferences at which reports of each of the departments were presented and discussed. These conferences were marked by the utmost frankness and cordiality, and Mr. Hutchinson's leadership encouraged the enthusiastic cooperation of his business associates.

In addition to his Institute membership Mr. Hutchinson was a member of the American Association for the Advancement of Science, the American Sociological Society, and the American Academy of Political and Social Science. Mr. Hutchinson also was a member of the Engineers' Club of New York, and of the Cornell University Club of New York.

Mr. Hutchinson's last illness really started prior to the recent winter convention. For two weeks he was down with a severe case of grippe from which he had not recovered when he returned to his office to take part in the rush of convention activities. Indomitable, he remained at his post until February 8, then to return to his sick-bed never to leave it alive.

## F. L. Hutchinson as Seen by Some of Those with Whom He Has Worked

CHARLES F. SCOTT (A'92, F'25, HM'29, president 1902-3)—Since Mr. Hutchinson entered Secretary Pope's office as an assistant nearly 30 years ago the Institute membership has increased from 1,800 to 18,000 and its activities have increased in like ratio. In this development he has been a quiet, constructive force. As secretary for a score of years he has shown rare tact and skill in carrying out the policies and instructions of presidents and boards, while exercising his own good judgment and impressing his own ideas. While other officers have come and gone he has been a continuing, directive, creative factor in the development of the Institute. He was a wide reader and student of affairs, interested in economic trends and social evolution, with high ideals of the responsibilities of the engineer as citizen. I realize the loss to our electrical group, and to the engineering profession. But to me there comes a keen sense of personal loss in the passing of my long-time associate and sympathetic friend. His enlarging vision and progressive ideals engendered increasing appreciation and regard. How deep these were I did not fully realize until the shock of the telegram announcing his death.

M. I. PUPIN, (A'90, F'15, HM'28, president 1925-6)—I have just received the sad news of the death of our national secretary. It is shocking news; it will cast a deep shadow of sadness over our beloved Institute, just as it has cast it over me. His death is an irreparable loss to the Institute and to all its friends and his friends. I am one of them. While president of the Institute I met Mr. Hutchinson often and got to know him quite intimately. I always admired him and loved him, and when I got to know him more intimately I admired him and loved him even more. He was a loyal servant of the Institute and one of its most devoted members. His memory will live long in the hearts of our Institute membership and it will be the memory of the most distinguished servant of the Institute.

GANO DUNN (A'91, F'12, president 1911-12)—F. L. Hutchinson was a great Secretary. As assistant to his beloved predecessor, Ralph W. Pope, a fine loyalty long concealed his abilities. Upon Mr. Pope's elevation to the Honorary Secretaryship, during my presidency in 1911-12, the country was scoured for a "big man" appropriate to the Institute's growth and increasing importance, but a trial period of a few months quickly discovered that we already possessed him. We were in the position of the mariners dying of thirst off the mouth of the Amazon, who were signaled to cast their buckets overboard. Hutchinson was an organization statesman whom the title of National Secretary did not adequately describe. His capacity for self-effacing leadership under successive presidencies of one-year terms contributed in unmeasured degree to developing the usefulness of the American Institute of Electrical Engineers to her members and the public, and to establishing her high rank in the respect of her sister societies and the engineering profession throughout the world. Solving his problems by methods that were creative and constructive, rather than controversial or regulatory, he knew the value of goodwill and cooperation untainted by self-interest. His word was his bond and his personality radiated humor and trustworthiness. Our Institute has lost her focus and thousands of her members a dear friend.

FRANK B. JEWETT (A'03, F'12, president 1922-3)—In the death of F. L. Hutchinson, the electrical engineering profession in America has lost much more than the services of a highly efficient and effective secretary. To many members of the Institute the news of his death will bring pangs of poignant grief in the knowledge that they have lost a sincere, kindly, and always helpful friend. For nearly two decades the development and growth of the Institute to its present position as one of the great engineering societies of the world has been very largely influenced by Mr. Hutchinson. During his occupancy of the secretarial office, presidents, no two of them alike in their methods or purposes have come and gone in a continuing procession. To one and all Mr. Hutchinson proved to be a sound and discriminating counselor whose advice has insured the avoidance of many a pitfall. Probably none of us appreciate fully the extent to which this quiet, unobtrusive, but forceful man has been the guiding force which has directed the course of the Institute in new and uncharted waters or through the turbulent seas of potential discord which are always present when many men of many minds meet for discussion and action. Never seeking to take the center of the stage even when his greater familiarity with and understanding of some situation would have made this easily possible, he nevertheless always, in his quiet way, offered exactly the right suggestion at exactly the right time. Many a brilliant piece of work for which someone else was acclaimed the author was in the last analysis the embodiment of his mature conclusions.

W. S. LEE (A'04, F'13, president 1930-1)—It is with a sense of deep personal loss that I learn of the death of F. L. Hutchinson. My close association with him during my term as president of the Institute afforded me an opportunity of knowing him intimately and of observing and appreciating his zeal and enthusiasm for the work of our organization and his indefatigable industry in its behalf. Not only was Mr. Hutchinson zealous in the cause of his own organization, but he was always ready and effective in his cooperation with other engineering and business organizations, and with the public in general. His ability to bring about effective coordination between our own and other organizations was unusual, reflecting not only the real capacity of the man but an earnestness of purpose and a sincerity that commanded the respect and admiration of all who knew him. In his passing not only the Institute but the engineering profession generally and the public have sustained a severe loss.

C. E. SKINNER (A'99, F'12, president 1931-2)—I was shocked beyond measure to learn of the death of National Secretary F. L. Hutchinson. The Institute has suffered an irreparable loss in his passing. For many years, as administrations came and went, Mr. Hutchinson has been the real guiding spirit of the Institute. To him far more than any other individual the Institute owes its present position among the national associations of the United States. He handled all of its relations with outstanding wisdom and unfailing tact. He was universally respected and admired by all who knew him whether it be through official contact or through mere personal acquaintanceship. Presidents and boards of the Institute have depended upon him and have placed implicit confidence in his execution of the exacting duties of his office. His death comes as a great personal loss to me as it must to every member of the Institute who has ever made his acquaintance.

C. W. RICE (A'97, F'12, secretary A.S.M.E.)—Mr. Hutchinson's contribution to every situation was constructive, broad-gaged and progressive. With an intimate, almost daily, association since 1904 when he first took up the work of the Institute, I cannot remember a single instance where he took a position with respect to any subject that was not favorable to the accomplishment of the highest purpose of the project in hand. He was particularly able in clearing up a situation and had the invaluable habit of putting the matter under discussion in such shape that the group could act. In this process he gave his opinion with such courtesy that one could differ and the discussion be absolutely impersonal. Then, with absolute mental honesty and unselfishness, he would phrase the consensus of opinion even though not with his own approval. Every member of the Institute and every engineer with whom he ever came in contact will join in the tribute that Mr. Hutchinson directly contributed to the enhancement of the prestige of the profession and by so doing advanced the influence of the Institute.

## Directors Meet During Winter Convention

The regular meeting of the board of directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, N. Y., January 27, 1932.

There were present: *President*—C. E. Skinner, East Pittsburgh, Pa. *Past-president*—W. S. Lee, Charlotte, N. C. *Vice-presidents*—H. V. Carpenter, Pullman, Wash.; H. P. Charlesworth, New York, N. Y.; L. B. Chubbuck, Hamilton, Ont.; W. B. Kouwenhoven, Baltimore, Md.; I. E. Moultrop, Boston, Mass.; and G. C. Shaad, Lawrence, Kans. *Directors*—A. E. Bettis, Kansas City, Mo.; L. W. Chubb, East Pittsburgh, Pa.; A. B. Cooper, Toronto, Ont.; A. E. Knowlton, New York, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New York, N. Y. *National treasurer*—W. I. Slichter. *National secretary*—F. L. Hutchinson, New York, N. Y.

The minutes of the meeting of December 4, 1931, were approved.

Reports of meetings of the board of examiners held December 22, 1931, and January 20, 1932, were presented and approved. Upon the recommendation of the board of examiners, the following actions were taken on applications pending: 260 Students were enrolled; 413 applicants were elected to the grade of Associate; 13 applicants were elected to the grade of Member; 26 were transferred to the grade of Member and one was transferred to the grade of Fellow.

In accordance with a suggestion adopted at the conference of officers, delegates, and members held in June 1931, and upon the recommendation of the committee on coordination of institute activities, the board voted to take the following actions:

1. The appointment of a national standing committee on transfers, composed of five Fellows and Members and including at least one member of the board of examiners, to prepare literature which will encourage members of the Institute who are fully qualified for the higher grades to submit their applications, and to coordinate the activities of the Sections in connection with transfers.

2. The encouragement of the appointment by each Section of a suitable committee to study the qualifications of its members and to urge those who are fully qualified for higher grades to apply for transfer.

### 1933 Meeting Schedule Adopted

A schedule of meetings for the calendar year of 1933, prepared by the committee on coordination of Institute activities, and including all requests for meetings that had been received by the committee, was adopted, as follows: January, winter convention, New York, N. Y.; May, North Eastern District meeting, Schenectady, N. Y.; June 26-30, summer convention, Chicago, Ill.; Aug. or Sept., Pacific Coast convention, Salt Lake City, Utah; Oct. or Nov., South West District meeting, St. Louis, Mo.

The rules governing the award of national and district prizes were amended to provide for competition for both the national and district prizes for initial paper by graduate students who are members or enrolled Students of the Institute.

Sec. 34 of the by-laws was amended to read as follows (the amendment consists of the addition of the words "having three or more Branches"):

> Sec. 34. To facilitate cooperation among the Student Branches, there shall be a committee on Student activities in each geographical district having three or more Branches, consisting of the vice-president, District secretary, and the counselors of all Branches within the District. The committee shall elect one of the counselors as its chairman, and may elect such other officers as it deems desirable.

Approval was given to the dates, October 10-13, of the Middle Eastern District meeting to be held in Baltimore in 1932.

The board approved amendments to the by-laws of the Lamme Medal committee, providing for a change from October 1 to November 1, each year, in the closing date for receipt at Institute headquarters of nominations for the medal.

Upon the recommendation of the standards committee, the following actions were taken:

Voted to relinquish the Institute's joint sponsorship of the sectional committee on wires and cables in favor of a single sponsorship under the electrical standards committee.

Approved the recommendation of the American Standards Association that the title of A.I.E.E. Pamphlet No. 100 be changed to "Recommended Practise in the Temperature Operation of Transformers."

Approved, as joint sponsor, a report of the sectional committee on radio on "Standard Vacuum Tube Base and Socket Dimensions" and "Manufacturing Standards Applying to Broadcast Receivers."

A report of a joint committee of engineering societies appointed to consider the question of the desirability of the organization of state engineering councils was presented, and upon the recommendation of this committee the board approved the general idea of encouraging the formation of state councils of professional engineers.

The president was authorized to appoint two representatives of the Institute on the council of the American Association for the Advancement of Science for the year 1932, and to appoint delegates to attend the annual meeting of the American Academy of Political and Social Science, Philadelphia, Pa., April 15-16, 1932.

Other matters were discussed, reference to which may be found in this and future issues of Electrical Engineering.

## A.E.C. Urges More State Councils

At the annual meeting of the assembly of the American Engineering Council in Washington, D. C. January 14-16, 1932, the assembly voted to adopt the following recommendations made by a joint committee composed of representatives of the American Society of Civil Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, and American Engineering Council, relative to the further formation of state engineering councils:

1. It is deemed essential for the advancement of the engineering profession that there be organized a state council of professional engineers in each state in which such a council does not already exist.

2. Each state council should be composed of representatives of the local sections of national engineering societies and the engineering and allied technical societies within the state.

3. The purpose of these councils should be to enable the engineering and allied technical organizations to render a more effective public service, and to contribute to the advancement of these professions. They may through appropriate channels communicate to the proper representatives of the state governments advice and suggestions relative to questions of legislation or administration and in the solution of which engineering and allied technical knowledge and experience may be involved or valuable, and may upon the request of local or regional organizations or in the absence of such organizations, render similar service in local affairs.

4. Membership in these councils should consist of any society or organization of the engineering or allied technical professions within the state whose chief object is the advancement of the knowledge and practise of engineering or of allied sciences, or the promotion of the interests of engineering or allied technical professions and which is not organized for commercial purposes. Membership in these councils should not be granted to individuals.

## Providence Meeting Plans Progressing

In addition to the student sessions on Friday, May 6, 1932, the meeting of the Institute's North Eastern District, No. 1, to be held in Providence, R. I., May 4-7, 1932, will include four technical sessions. The symposium on "Traffic Control Systems" will attract considerable attention. Other sessions will be sponsored by the machinery, and transmission and distribution committees, and at the fourth session there will be presented several selected papers of general interest.

The dinner will be held Thursday evening, May 5. Also a wide range of inspection trips has been planned by the local committee. Headquarters will be at the Providence-Biltmore Hotel. Further details of this District meeting will be given in the April issue of Electrical Engineering.

# Unemployment Relief Being Afforded by Institute and Other Engineering Groups

UPON the recommendation of the Institute's committee on the economic status of the engineer, the board of directors unanimously adopted a resolution at a meeting held in Kansas City, Mo., October 23, 1931, providing for unemployment relief. As reported on p. 975 of ELECTRICAL ENGINEERING for December 1931, this resolution recommended that each Section formulate and carry out a plan of relief embodying substantially the following features: That in each locality a committee of engineers be organized, composed preferably of representatives of all the engineering groups in the community and working in close cooperation with local sections of other societies and engineering groups, and so organized as to work in close cooperation with other local civic relief organizations. Further recommendations regarding organization were made, and it was suggested that these local committees conduct surveys of the need for relief and for local opportunities for constructive work or employment, using so far as possible the aid of engineers at present unemployed. Further, it would be the purpose of this committee to collect and administer funds for loans and remuneration to deserving unemployed engineers, and to perform such other duties as might be deemed advisable in each particular community.

### SECTION ACTIVITIES SUMMARIZED

In response to this resolution, letters were written to each Section urging the consideration of organizing, in conjunction with other engineering groups, an engineers' unemployment relief committee. As the conditions in different communities vary widely, it is difficult to generalize upon the results which have been obtained. In some communities unemployment among professional engineers has been widespread, and much work has been done by the committee in alleviating this condition. In other sections, particularly those far from manufacturing centers, the situation has not been acute, and frequently the local civic unemployment relief organization has been considered adequate.

In those localities where relief work has been undertaken, the methods of attack vary widely. In certain communities the local situation has been such that the Section of the Institute has taken full responsibility for collection of funds and other relief work among the electrical engineers of the district. The San Francisco Section of the Institute has reached the conclusion that financial aid in the form of loans is the most effective means of relief for the conditions found in their particular district, and are concentrating on this form of activity. The Boston Society of Architects and the engineering societies of Boston, Mass., are cooperating in the collection of funds to be distributed as salaries to unemployed members of the profession who assist in emergency planning and research work to be used "in the advancement of city planning and regional data, in suggestions for rehabilitation of depreciated properties and districts, for the elimination of slums, for the long-range planning of the physical development of our various municipal departments, in economic surveys of various kinds, valuations or appraisals for various purposes, and in other similar projects."

More frequently, the Section cooperates actively with other relief bodies and places its special emphasis upon assisting the electrical engineer. Questionnaires have been sent out by many Sections and registration of those unemployed undertaken. Industries have been canvassed in an attempt to learn of positions available and the qualifications essential in filling these. A particularly valuable part of the work undertaken is a study of the fitness of the man for the position open and the economic necessity for aiding each individual. Considerable effort has been made to promote emergency work to be undertaken by the local and State governments; and toward the adoption of the scheme of spreading work as far as possible among the largest numbers of men, both in government and industrial activities. Among the Sections of the Institute which have been particularly active are, Atlanta, Boston, Chicago, Cincinnati, Cleveland, Connecticut, Dallas, Denver, Detroit-Ann Arbor, Ft. Wayne, Los Angeles, Milwaukee, Minnesota, Philadelphia, Portland, Rochester, San Francisco and Seattle.

Surveys have been conducted by practically all Sections of the Institute. Some of these indicate that there is very little unemployment among electrical engineers in the Section. Also, the surveys indicate that the largest part of the unemployed are young men, few of them with dependents, and most of them having homes to which they may return. Educational communities, especially, appear to be free from an acute unemployment situation, and in general it appears that throughout the country electrical engineers have not been so adversely affected as many other engineering and non-engineering groups.

### NEW YORK CITY PLAN

Perhaps the most thorough and complete scheme for coping with the immediate unemployment problem is that developed in New York, N. Y., for the metropolitan district. A very definite method of procedure in collecting and distributing funds and otherwise providing unemployment relief has been set up and is functioning to aid a very large number of persons. As the details of this plan may be of assistance to other communities, space will be given here for its description.

Action was initiated by the American Society of Civil Engineers to form a committee to aid unemployment among engineers in this district. As a result of this action, the first meeting of the Professional Engineers Committee on Unemployment, known in New York as the P.E.C.U., was held October 21, 1931, with representatives from the four national societies of civil, mining, mechanical, and electrical engineers present. At this meeting it was decided that the engineering profession should carry on its own unemployment relief program. This decision was reached because the regularly constituted relief agencies in the New York City region held to an exceedingly rigorous standard of destitution, and further because part of the program was to prevent, so far as possible, members of the engineering profession from reaching this condition.

Later it developed also that it was exceedingly difficult to obtain information from those in need of relief. Engineers as a class have never been given to talking of their troubles. However, it was found that these men would speak more freely to another engineer than to a professional social worker.

A general committee of about 40 members consisting of engineers prominent in the profession, whose names were ample evidence of the high character of the undertaking, was immediately formed. This general committee, under the chairmanship of H. de B. Parsons, appointed an executive committee of six men with J. P. H. Perry, chairman, to carry on actively the work of soliciting funds and of unemployment relief. This committee directs some dozen standing committees, which are divided roughly into two groups: those subsidiary to a finance committee, chiefly concerned with the collecting of funds; and those working under a relief committee, providing direct relief in such forms as employment, loans, legal aid, and engineering education.

### ENGINEERS CANVASSED TO OBTAIN BASIC DATA

The first step was to register the unemployed engineers in order to get an accurate estimate of the problem with which the committee was confronted. A postcard was first sent out to the metropolitan membership of the four societies advising them of the formation of the committee, stating that its object was to devise methods by which engineers in need of assistance would be looked after by their brothers in the profession, and also advising members in a position to do so to be prepared to contribute to the movement.

A tentative organization was formed, headquarters established in the Engineering Societies Building, New York, and preparations made to register the engineers as soon as they came in. At a mass meeting held in the Engineering Auditorium on November 9, 1931, prominent speakers outlined the program to be carried out and also called for suggestions. The notice of the meeting carried this paragraph: "If you are unemployed and in need of assistance we urge you to register in person before November 10, at Room 201, 29 West 39th Street, New York City." Registration was very slow at first but increased rapidly from day to day as the movement gathered impetus.

Two policies were stated definitely at the beginning of the movement: (1) that the P.E.C.U. in affording relief would make no distinction between members and non-members of the four engineering societies; and (2) that all money collected for relief should be applied to relief purposes only, the necessary administrative funds to be obtained from other sources.

Subsequently, however, the demands placed upon the committee required a change in the policy regarding relief to unemployed engineers regardless of whether such engineers were members or non-members of the four societies. At a meeting of the executive committee on February 8, 1932, it was decided that with respect to placement of unemployed engineers on P.E.C.U. payrolls only members or former members of the four societies could be considered. However, in the case of placement of unemployed engineers on the payrolls of public organizations the present policy of assisting both members and non-members would be continued. Loans are to be made only to members or former members of the four societies. It was felt that these changes were justified by the fact that contributions have been made entirely by the membership of the four societies.

From the very first, the executive committee of the P.E.C.U. recognized that its problem from an administrative point of view was relatively more difficult than that confronting the great city committees the principal duty of which was to collect funds. Once funds were collected by such committees they were turned over to the organized charities of the city for distribution. The P.E.C.U., however, had not only to collect the money, but also to build up an organization composed wholly of engineers who were largely volunteer workers and also entirely inexperienced in social welfare work. The problem was one of organizing to spend the money with justice but leaving no loophole for scandal. Great care has been exercised in safeguarding the expenditure of this money, not only in making just loans, but in handling payrolls carefully.

### "MADE WORK" BUREAU ESTABLISHED

One of the first steps was to make contact with the regularly established relief organization, which is the New York branch of the President's Organization on Unemployment Relief, and which had already established a "made work" bureau. The officials of the latter organization because of the obvious advantages of such aid accepted the offer of having this "made work" carried out with proper engineering supervision; however, because the destitution requirements of these regularly appointed agencies were such that many engineer applicants in need of help were unable to qualify, the P.E.C.U. established its own "made work" bureau.

### ORGANIZATION OF ENGINEERS DEVELOPED

The organization of the P.E.C.U. was developed by a gradual process to its present stage. In addition to the general and executive committees already mentioned, is a committee on clearance, its chief duty being to maintain contacts with existing relief agencies; a committee on organization to take care of problems of internal administration and to act as a comptroller of the administration funds; and a publicity committee. The remainder of the work is divided into two groups, financial and relief.

The work of the finance committee is concerned with the raising of funds for relief purposes only. So far, this has been done by appeals to the metropolitan district members of the four engineering societies, principally by letter. A special list of engineers believed to be able to make sizeable contributions has been approached by direct solicitation. Money collected by the finance committee is deposited with United Engineering Trustees, Inc., which acts as the treasurer of the P.E.C.U. There are many obvious advantages inherent in the use of an established concern for this purpose. The money is then turned over to the organization paymaster and timekeeper for distribution.

### ACTIVITY OF RELIEF COMMITTEE

The relief committee supplies direct and indirect relief in all forms, together with the developing and prosecution of plans for "made work." The working of this committee perhaps may be presented most easily by considering the procedure of an engineer presenting himself for assistance. He first goes to the committee on registration where he fills out duplicate cards, one of which goes to the registrar who determines his engineering status and decides whether or not it entitles him to relief from the committee; the other card is filed with the committee on research and vital statistics. Cross-reference of these latter cards is made to show the applicant's so-called "degree of destitution" as follows:

**Table I—Dollar Value Obtained by Feb. 15, 1932**

| | |
|---|---|
| Cash collected | $ 68,928.98 |
| Unpaid pledges | 14,488.63 |
| Contributed for administration | 5,318.91 |
| State and federal contributions to carry on work of the U.S. Geological Survey | 24,000.00 |
| Relief obtained by P.E.C.U. men through others (wages, etc.) | 99,025.00 |
| Certain relief funds for use in portions of United States not covered by P.E.C.U | 5,683.35 |
| Total | $217,444.87 |

1. If in need of immediate aid
2. If his resources will last one month
3. If his resources will last for longer periods

The engineer is next interviewed by the department of employment which endeavors to place him immediately in some gainful occupation, always giving preference to those in immediate need. If a member of one of the four societies, he is also automatically registered with the Engineering Societies Employment Service for a permanent position.

If the interview with the registration committee indicates that the engineer requires immediate financial help or legal advice, he is sent to the department of certification of loans and payroll where, if deemed advisable, he is given a requisition on the treasurer for a loan, in return for which he gives his note which is non-interest bearing and payable on demand. Clothing, if necessary, is made available by the social service committee sponsored by the Engineering Woman's Club. Sound advice or legal assistance is made available without expense by the legal counsel.

Arrangements have been made with Columbia University whereby unemployed professional engineers are admitted to lecture courses on engineering and allied subjects without fee and without academic credit. In this way they not only may improve their general mental attitude, but may place themselves in a position to increase their earning capacity at the end of the economic depression.

There is a committee on plans, the function of which is to survey and chart the possibilities for "made work," having an allied committee charged with the responsibility of putting these plans into effect. A committee on opportunities in business and industry was started the first of the year to make contact with various business and industrial organizations, bringing to their attention the possibility of having their plants surveyed by unemployed engineers so as to improve plant layout and processes of manufacture, and increase efficiency.

WORK ACCOMPLISHED

Direct contact is maintained between the P.E.C.U. and the Engineering Societies Employment Service to provide permanent positions, when available, for the registrants. These two bodies, however, are entirely separate, the P.E.C.U. being motivated to provide prompt relief for engineers in immediate need and register all engineers out of work. It is financed entirely by voluntary gifts.

On February 15, 1932, the total registration had reached 1,900, somewhat less than half of which consisted of members of the four engineering societies. Of those registered on that date, immediate help had been found to be needed by [illegible]. A total of 446 already had been placed in positions. Contact is maintained with registrants and the records revised from time to time. As shown by Table I the total dollar benefit obtained by the P.E.C.U. for the engineering profession was $217,441.87.

In addition to the direct financial benefit, there are of course many other advantages being derived from this plan, and it is intended to support actively the various forms of unemployment relief so long as the emergency exists. Plans are now being made for a more direct canvass of professional engineers who are in a position to contribute. The registration continues to increase each week, and as many of these are cases of destitution, the committee is spurred to greater activity.

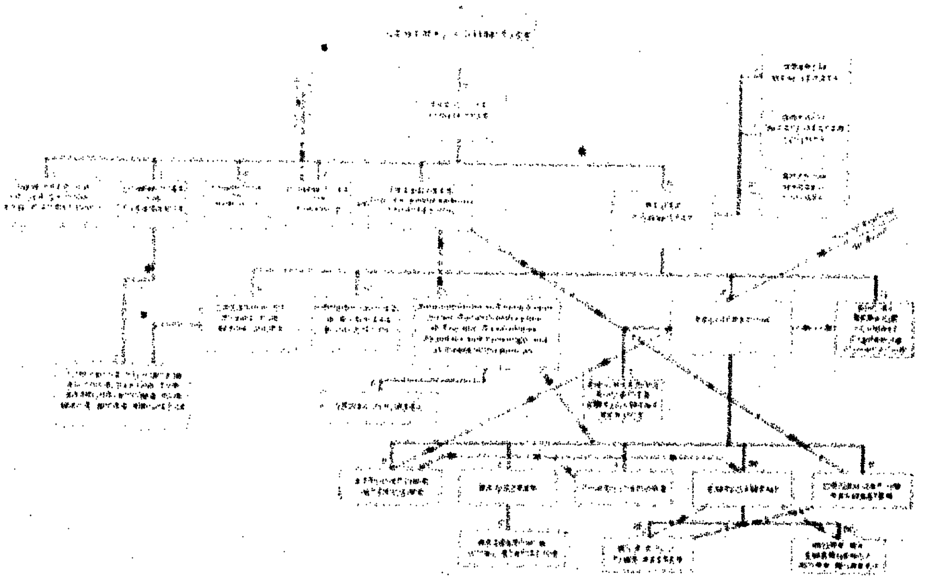
ENGINEERS' NATIONAL RELIEF FUND

Based upon a contribution of $5,000 received from President Hoover, a fund for national use is being built up, administered by a separate committee composed of F. C. Hutchinson, Chairman, W. G. Atwood, Langdon [illegible], and E. B. Meyer, representing, respectively, the mechanical, civil, mining and electrical engineering societies, and with Ernst Hartford, assistant secretary of the American Society of Mechanical Engineers, acting as secretary of the committee. The policy has been adopted for the use of the fund as a loan primarily for members of the four national societies, or to members of local societies with which the local sections of the four societies are affiliated. The loans will be the basis of a revolving fund, and will be made only for brief periods consistent with providing an emergency service.

Because of the limited size of the fund, it is felt that so far as possible the engineers in the larger communities where sections of the societies are organized should care for their own engineering dependents, so that some latitude will be provided for aiding the very considerable number of engineers living in isolated parts of the country where there is no organized group to take interest in them.

AMERICAN ENGINEERING COUNCIL PLAN

The American Engineering Council also is active in unemployment relief, working through state councils and local committees. While assisting in relieving the immediate unemployment situation, the more important phases of the work being carried on by this body probably are those concerned with the permanent stabilization of employment and industry, and in urging local, state, and national governments to adopt measures which may relieve the present situation and be effective in preventing recurrences of the present cycle. A recent report of this body includes the prediction that a marked social advance will result from the present widespread relief activity; better relations between employers and employees are being built up, a sober view of public financing is being taken, and corporate management is being shaped along sounder lines. It is asserted that these and other constructive developments arising from the depression will make for a more stable economic organization.



Organization chart of the New York City Professional Engineer's Committee on Unemployment

## Sectional Committee on Noise Recommended

The organization of a sectional committee on noise measurement under the procedure of the American Standards Association was recommended by a general conference of 32 representatives of 18 national bodies held in New York, N. Y. on January 29, 1932. It also was recommended that this committee function under the technical leadership of the Acoustical Society of America. The scope of the project as recommended by a steering committee, consisting of Prof. V. O. Knudsen, E. E. Free, P. L. Alger (F'30), H. R. Summerhayes (M'16), R. G. McCurdy (M'28) and Dr. Harvey Fletcher (F'30), is the preparation of general standards of nomenclature, units, scales, and measurement in the field of acoustics, with special reference to noise measurements.

It was the feeling of the Institute's committee on sound under the chairmanship of P. L. Alger that the widespread interest in noise and the rapid development now going on in noise measuring instruments make desirable national standards in this field. Already there are eight or more national noise committees, most of which have definitely set before themselves the task of preparing standards of noise measurements. Hopeless confusion must result unless these various projects are coordinated by some such means as this recently organized sectional committee under the A.S.A. Therefore the A.I.E.E. committee on sound cordially endorses the formation of this sectional committee and expresses its desire to carry out its work on noise standards through this organization. It is the further feeling of the Institute's committee that the scope of the sectional committee should be as stated by that body, namely, the preparation of general standards of noise measurements, and that test procedure and standardized methods of defining the noise characteristics of particular apparatus in particular locations should be left to the individual member organizations for later development.

The concentration of the sectional committee's work for the present chiefly on the standardization of nomenclature, units, and scales should become the basis for further progress in the science of noise measurement. The complex nature of noises and their effects upon the ear introduce confusion in the measurement of noise, and none of the noise meters yet designed can translate the approximate physiological and psychological effects of noise into definite units of measurement. Definition and standardization of these factors alone will do much to make possible real progress in the engineering application of our knowledge to the reduction in noise of apparatus.

# Letters to the Editor

## The Reactive Voltampere Conventions

*To the Editor:*

When we say that the "power factor" is leading we mean by tacit agreement that the current leads the voltage. Further, when we plot these as vectors, we are required to use a counterclockwise rotation to agree with mathematical custom.

Now if leading reactive voltamperes are called negative, there is a reversion in appearance to the old clockwise diagrams, leading voltamperes appearing to lag behind the power unless a clockwise sense is assumed. If power and reactive voltamperes are considered as true double-frequency vectors then we are forced to define leading reactive voltamperes as positive in order to maintain the counterclockwise convention. In this I am assuming that the polarities of mathematics must be accepted in all Cartesian charts.

To argue that lagging reactive voltamperes should be positive because $R + jX$ represents an inductive impedance is useless, for the inverted argument that it should be called negative because $G - jB$ represents an inductive admittance is just as good and more to the point in constant voltage systems.

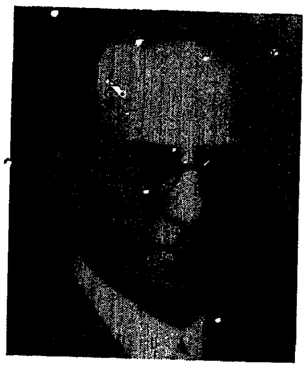
Be consistent, call leading reactive voltamperes positive and maintain the appearance of counterclockwise rotation.

Very truly yours,

V. G. SMITH (A'26)
(Assistant Professor of Electrical Engineering, University of Toronto, Toronto, Canada)

[**Editor's Note:** This letter discusses one division of the "Proposed Definitions of Power System Terms" (see ELECTRICAL ENGINEERING for February 1932, p. 106-7) developed by a special subject committee of the A.I.E.E. committee on power transmission and distribution. Further discussion is invited on any of the proposed definitions.]

# Utility Executive Advanced



F. B. LEWIS

F. B. Lewis, formerly vice-president and assistant general manager of the Southern California Edison Company, Ltd., Los Angeles, has been promoted to the position of vice-president and general manager. Mr. Lewis graduated from Rose Polytechnic Institute at Terre Haute, Ind., 26 years ago, and has been with the Edison Company continuously since that time. Among his early accomplishments was the installation of the first 33-kv. transmission line by the Edison company to bring power from Santa Ana River Canyon to Los Angeles, Calif.

# Engineering Foundation

## Election of United Engineering Trustees Held

Officers elected to serve United Engineering Trustees, Inc. for the year 1932 have been announced. H. A. Kidder (F'29) was elected president, and H. V. Coes and Col. A. S. Dwight were named vice-presidents. Dr. A. D. Flinn, director of the Engineering Foundation, will serve as secretary, and C. P. Hunt as treasurer. Other members of the board of trustees were chosen as follows: F. E. Winsor, Boston, Mass.; C. A. Mead, Newark, N. J.; A. S. Tuttle, New York, N. Y.; G. D. Barron, Rye, N. Y.; R. M. Roosevelt, New York, N. Y.; E. R. Fish, Hartford, Conn.; F. A. Schaff, New York, N. Y.; H. P. Charlesworth (F'28), New York, N. Y.; and A. W. Berresford (F'14) New York, N. Y.

The United Engineering Trustees was established in 1904 as the United Engineering Society "to advance the engineering arts and sciences in all their branches, to further research in science and engineering, to maintain a free public engineering library, and to advance in any other manner the profession of engineering and the good of mankind." As the joint agency of the four national societies representing the civil, mining, mechanical, and electrical engineers, it owns and administers the Engineering Societies Building at 33 West 39th Street, certain endowment and other funds, and other properties committed to it. Through the Engineering Foundation, the library board, and the administrative department, it aids research in engineering and the sciences, operates the Engineering Societies Library, and carries on other activities.

# Standards

## Standards Committee Meets During Winter Convention

At the meeting of the standards committee of January 26, 1932, a number of subjects was discussed. Attention was called to a difference between A.I.E.E. standard No. 20, "Air Circuit Breakers," and the standard of the National Electrical Manufacturers Association for the same apparatus. The A.I.E.E. rule permits a 30-deg. cent. rise on contacts whereas N.E.M.A. permits only 20 deg. After receiving the report of the A.I.E.E. subcommittee which developed "Air Circuit Breakers" the standards committee approved a change in the A.I.E.E. Standard to 20 deg. unless objection is registered by the principal users of air circuit breakers.

At this same meeting, the recommendation of the standards council of the A.S.A. that the sponsorship for the sectional committee on wires and cables, now vested in nine associations including the A.I.E.E., be transferred to the sole sponsorship of the electrical standards committee was recommended to the board of directors for approval. This newly-organized electrical standards committee (as described on p. 845 of ELECTRICAL ENGINEERING for Oct. 1931) is the joint body representing eleven organizations and working under the A.S.A.

A suggestion of the scopes committee

of the electrical standards committee that the title of A.I.E.E. pamphlet No. 100 "Recommendations for the Operation of Transformers" be changed to "Recommended Practise in the Temperature Operation of Transformers" was presented to the standards committee and approved. No. 100 now will go to letter ballot of the standards council of the A.S.A. for approval as American recommended practise. Also, in accordance with a suggestion of F. D. Newbury (F'21) the standards committee on January 26 recommended an extension of scope of the sectional committee on transformers to cover all transformers and other equipment contained in A.I.E.E. standards No. 12 "Constant-Current Transformers," No. 13 "Transformers, Induction Regulators and Reactors," No. 14 "Instrument Transformers" and also pamphlet No. 100 "Recommendations for the Operation of Transformers."

The committee recommended to the board of directors the approval by the Institute as a joint sponsor of the reports of the sectional committee on radio dealing with "Standard Vacuum Tube Base and Socket Dimensions" and "Manufacturing Standards Applying to Broadcast Receivers."

A report made up of definitions relating to telemetering has been received from the instruments and measurements committee. As the sectional committee on electrical definitions has a subcommittee under Dr. J. F. Meyer (M'13) dealing with instruments and testing, the report of the technical committee was referred to that group for consideration and inclusion in their report.

## Form and Arrangement of Published Standards

The report of the special committee on form and arrangement of published standards was made under date of November 30, 1931 and now is available in pamphlet form. This report is the work of a special committee of the American Standards Association, appointed in January 1925. The committee's objective has been the preparation of publication practises to be recommended by the A.S.A. for use by all bodies developing standards particularly under A.S.A. procedure.

The committee selected a page size of 7¾x10⅝ in. but also recognized three other suitable sizes. Alternative procedures are included in a number of other instances. It is hoped that experience in using the recommended practises will permit eventual elimination of the alternatives. Copies of the report may be obtained from A.S.A. headquarters, 29 West 39th Street, New York, N. Y.

# Personal

J. C. Parker (A'04, F'12) who has been chosen to succeed M. S. Sloan to the presidency of the Brooklyn Edison Company, Brooklyn, N.Y., has been its vice-president in charge of engineering since 1926. Besides being possessed of a wide experience in the many practical fields of application of the profession he has had considerable experience also in the academic field. For some time he was an instructor in mechanical and electrical engineering at Union College, Schenectady, N. Y., under Dr. C. P. Steinmetz, giving in addition a course in thermodynamics and another in the mathematics department. His B.S. in M.E. was conferred upon him by the University of Michigan from which he was graduated in 1901, this same institution the next year conferring upon him his A.M. degree for advanced work in mathematics, physics, and structural engineering. In 1904, his E.E. degree was won also from the University of Michigan by work done *in absentia*. Returning to the industrial field in 1904 Mr. Parker became assistant to the engineer in charge of construction and design for the Ontario Power Company's plant at Niagara Falls, the largest hydroelectric undertaking of its time. Upon completion of the first section of the Ontario Power Company's plant in 1905, he went to Buffalo as assistant to the vice-president and chief engineer of the construction company building the lines of the Niagara, Lockport, and Ontario Power Company from Niagara Falls to Syracuse. This was the first 60,000-volt transmission line, and the engineering for it was done by R. D. Mershon (A'95, F'12) past-president of the Institute. In this same year Mr. Parker became mechanical and electrical engineer of the Rochester Railway & Light Company, in charge of the engineering department; to this engineering work shortly was added the organizing of the power sales engineering division and economic investigation of power and illuminating conditions in company works. In 1915 the University of Michigan recalled him as professor of electrical engineering in charge of its department of electrical engineering, and this was the position from which he resigned in 1922 to become electrical engineer of the Brooklyn Edison Company. While primarily interested in higher mathematics and physics, Mr. Parker later became deeply concerned with the practical aspects of standardization and the simplification of production, design and construction. He was chairman of the Institute's delegation to the American Standards Association, and December 9, 1931, at the annual meeting of the American Standards Association was elected to serve (1932) as vice-chairman of the Standards Council. He has served the Institute in several capacities including that of vice-president (1921-2). He is a member of the American Society of Civil Engineers, the American Society of Mechanical Engineers, and of the Engineers' Club of New York.

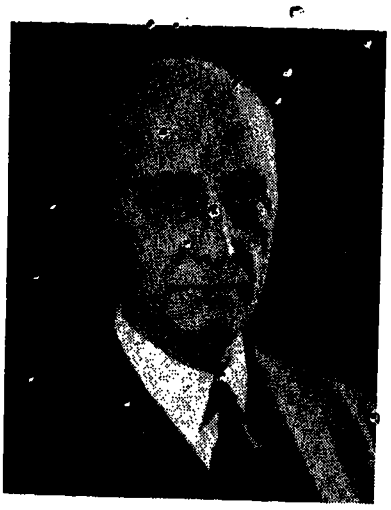
J. C. PARKER

Giuseppe Faccioli (A'04, F'12) who retired from active professional service May 27, 1930, when he withdrew from the office of works engineer and associate manager of the Pittsfield works of the General Electric Company, has been chosen as the A.I.E.E. Lamme medalist for 1931. Mr. Faccioli, a native of Italy, graduated with high honors in both mechanical and electrical engineering from the Institute of Technology at Milan. He came to this country at the age of 25 and spent the first year of his career upon the design of a-c. machinery. He attracted the attention of the late William Stanley, inventor of the transformer, and through this association and that with other pioneer engineers, Mr. Faccioli has accomplished professional work which forever will be outstanding in the electrical engineering world. High tribute has already been paid him by men prominent in the profession; he has been hailed

GIUSEPPE FACCIOLI

as "a mathematical genius and a veritable wizard" in his chosen calling, but as "none the less human" in consequence of this personal achievement. Especially have the younger engineers gained from him knowledge and inspiration. His work with the General Electric Company covered a span of 25 years, and upon his retirement he was presented with a testimonial, brilliantly hand illuminated and signed by more than 150 names of the men who had worked with and for him during that period of his own service to the company and to the profession. This presentation was made in Schenectady, N. Y., by the late Doctor L. T. Robinson, (A'04, F'12), then in charge of the company's general engineering laboratory, with S. H. Blake (A'03, F'17), general engineer of the General Electric Company, and J. L. R. Hayden, the other member of the company's general standardizing committee. Always keenly interested in the A.I.E.E., Mr. Faccioli has been an untiring worker in its behalf, serving on many of its committees and as manager and vice-president. In 1928 he was decorated by Mussolini with the emblem of the Commandant of the Crown of Italy. Mr. Faccioli in relinquishing active duties with the General Electric Company becomes a consulting engineer, retaining his keen interest in all affairs of the organization.

PHILIP TORCHIO


F. W. SMITH

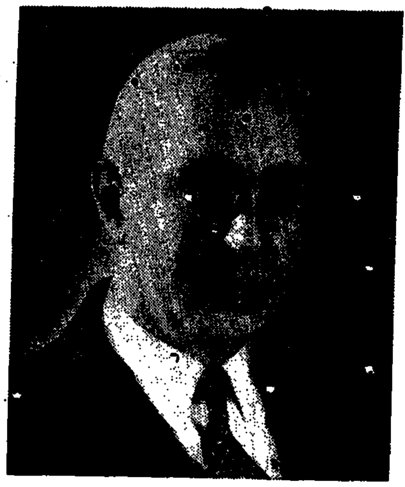
W. D. COOLIDGE

Philip Torchio (A'95, F'12) vice-president of the New York Edison Company, New York, and past-president of the New York Electrical Society, has been elected by his board of directors to serve as senior vice-president of the New York Edison Company. Mr. Torchio was born in Como, Italy, in 1868 and came to New York in 1893. He became a naturalized citizen and since 1895 has been with the New York Edison Company interests. He served for many years as a consulting engineer for affiliations of the Consolidated Gas Company and the New York Edison: namely, United Electric Light and Power Company, New York and Queens Electric Light and Power Company, Yonkers Electric Light and Power Company, the Westchester Lighting Company, and the Bronx Gas and Electric Company. He pioneered in the introduction of the 132,000-volt underground cable in this country and is the author of considerable technical literature on the economics of electric light and power generation and distribution. He is a member of Franklin Institute, has served the Institute as chairman on committees on power transmission and distribution, power stations, and economics of electric service, and as a member of the standards committee, the United States National committee of the International Electrotechnical Commission, electrical machinery committee, meetings and papers, power test code, and protective devices committees. In the Association of Edison Illuminating Companies, he has acted as chairman of the committee on high potential disturbances, symposium on system troubles, committee of conferees on armature coil temperatures of large generators and the committee on high tension cables. Also he has been a member of the committee on power generation and the committee on standards, and a representative on sectional committee on ratings of the American Engineering Standards Committee, now the American Standards Association. He was chairman of the National Electric Light Association's committee on underground construction and of the joint conference committee on standards. Mr. Torchio was a member of the American committee on electrolysis, the American Commission to the World Power Conference, American Engineering Standards committee sectional committee on rating of electrical machinery and the sectional committee on insulated wires and cables.

F. W. Smith (A'05, M'12) who has been serving the United Light and Power Company of New York as its vice-president and general manager, has been chosen to succeed M. S. Sloan as president of the New York Edison Company and the United Electric Light and Power Company. Already Mr. Smith is chairman of the board of directors of the New York and Queens Electric Light and Power Company and president of the Brush Electric Illuminating Company of New York. The year 1930 rounded out an uninterrupted 52-year service with the United Electric Light and Power Company, which he joined as a thirteen-year-old office boy in 1880 when the company was known as the United States Illuminating Company. This was two years prior to the opening of the Pearl Street station of the Edison Company and three months after the perfection of the incandescent lamp by Thomas A. Edison. In 1889 he was appointed paymaster for his company which then had become the United Electric Light and Power Company; 1891 found him assistant auditor, and eight years later he was elected to the office of assistant secretary. A year later he became secretary of the Brush Electric Illuminating Company, of which he in 1929 became president and a director. Of the United Electric Light and Power Company he was made secretary in 1905, vice-president in 1912 and general manager in 1916. In 1926 Mr. Smith was elected chairman of the board of the New York and Queens Electric Light and Power Company; in February a year ago he was made vice-president of the New York Edison Company. He has been active also in the affairs of the National Electric Light Association for many years, of which he was elected vice-president in 1919 and president in 1922. Under his presidency the association expanded considerably, Mr. Smith being largely instrumental for the formation and organization of its geographic sections. He has been chairman of many of the association's committees, and an active member of a large number of others; for sixteen years he has served as chairman of its lamp committee and is still a member of the public policy committee. In its early days he was actively connected with the Electric Vehicle Association and in 1923 was its president. This was shortly before the association became a part of N.E.L.A. activities. In addition to several other technical organizations, Mr. Smith is a member of the Electrical Association of New York, the New York Electrical Society and the Engineers' Club. In his long and assiduous service in the electrical profession he has commanded confidence as a conservative, open-minded administrator, giving particular attention to all complaints which came to him, and the maintenance of cordial public relations.

W. D. Coolidge (A'10) associate director of the research laboratory of the General Electric Company, Schenectady, N. Y., on February 24, 1932 received the Washington Award for his "scientific spirit and achievement in developing duc-

H. A. KIDDER



B. F. Kutcher Studio

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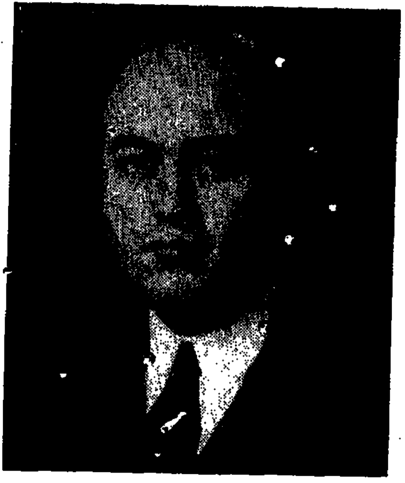


A. H. KEHOE

tile tungsten and the modern X-ray tube." A native of Hudson, New York, Doctor Coolidge was graduated from Massachusetts Institute of Technology in 1896, at that time receiving his B.S. degree; in 1899, he won his Ph.D. from the University of Leipzig. At M.I.T. he has been assistant in physics, instructor in physico-chemistry and assistant professor in physico-chemical research. In 1905 he associated himself with the General Electric Company and ever since 1908, when he was made assistant director has been in the research laboratory. In 1914 he received the Rumford Medal for his invention and application of the ductile tungsten. This medal is awarded bi-annually by both the Royal Society and the American Association of Arts and Sciences, "for the most important discovery and useful improvement" during the two years immediately preceding the date of award. He has also been the recipient of the Franklin Institute's Howard N. Potts Medal (1926) "in consideration of the originality and ingenuity shown in the development of a vacuum tube that has simplified and revolutionized the production of X-rays," and the Louis Edward Levy Gold Medal, another Franklin Institute award for professional achievement. In 1927 he received the gold medal of the American College of Radiology and the Hughes Medal of the Royal Society, London. Doctor Coolidge enjoys extensive membership in the scientific and technical groups, among them being the American Chemical Society, the American Electrochemical Society, the American Physical Society, the American Academy of Arts and Sciences, and the Washington Academy of Sciences. Also he is an honorary member of the American Roentgen Ray Society, the American Radium Society, the Radiological Society of North America, the Roentgen Society (of England), Societe de Radiologie Medicale (of France), and Nordick Forening for Medicinsk Radiologi.

**H. A. Kidder**, (A'06, F'29) superintendent of motive power, Interborough Rapid Transit, New York, has been elected president for 1932 of the United Engineering Trustees, Inc., joint agency of the four national engineering societies, 29 West Thirty-Ninth Street, New York, N. Y. His appointment as electrical superintendent of the Interborough Rapid Transit came in 1914, following his employment in the railway motor department of the General Electric Company; six years later he was advanced to assistant superintendent of motive power, his further advance to superintendent coming in 1921. Mr. Kidder has served the Institute in a multiplicity of committee connections including power generation, power stations, headquarters, standards, special committee on Institute prizes, the engineering profession, special committee on technical activities, executive, finance, coordination of Institute activities, Edison Medal, transportation, U.S. National committee of International Electrotechnical Commission, and meetings and papers (now technical program committee) and still is active as Institute representative to the United Engineering Trustees, American Engineering Council, on the A.I.E.E. board of examiners, law, and legislation. For three years he was on the board of directors, served one year as chairman of the Institute's New York Section, and for two years as a vice-president. He is a past-president of the New York Electrical Society, and a member of the American Electric Railway Association. At present Mr. Kidder is devoting a great deal of his time to the Professional Engineers' Committee on Unemployment, on which he is serving as chairman of the finance committee.

**Kern Dodge** (A'02, M'12) consulting engineer and aviation enthusiast of Philadelphia, Pa., who recently received appointment as director of public safety of the City of Philadelphia, is a native of Chicago, and was graduated from Drexel Institute in 1907. For four years, before and after school of each day, he took charge of the electric plant at the works of the Link-Belt Company, where finally in complete charge of new electrical equipment, he changed over the entire system to electric drive. He was placed in charge of the electrical equipment at the Harrison Safety Boiler Works of Philadelphia, where he later entered into a partnership with Charles Day (now of Day and Zimmerman) in a consulting engineering practise. This company subsequently became Dodge, Day and Zimmerman, and Mr. Dodge's work was chiefly in connection with public utility properties, his earlier consulting work having been the design, layout, and construction of power plants, transmission lines and substations. A registered professional engineer in the State of Pennsylvania, Mr. Dodge now is a director of the Link-Belt Company, a member of the New York Electrical Society, the American Society of Mechanical Engineers, and the Illuminating Engineering Society. He is said to be an expert in the field of aviation, and the first engineer in the history of Philadelphia to be appointed director of public safety. This also is the first political appointment Mr. Dodge has had.

**A. H. Kehoe** (A'12, F'25) electrical engineer of the United Electric Light and Power Company was one of those chosen vice-president of the New York Edison Company at a recent meeting of its board of directors. As superintendent of transmission and distribution and for over nine years electrical engineer of the United Electric Light and Power Company, as well as a member of several important subcommittees of the electrical apparatus committee of the National Electric Light Association, Mr. Kehoe has established for himself a reputation of capability. His estimable record with the United Electric Light and Power Company started in 1911, in the laboratory on special investigations and design of new equipment. He progressed to important work in the meter department, and thence to the engineering department, where his duties were in connection with substation design and construction, also distribution system engineering in the arrangement of cable systems and service, transformers on network systems and the location and elimination of faults, and the maintenance of the continuity of service. He also worked on transmission system design and protection. He has contributed to technical literature, setting forth interesting and instructive phases of his own valuable experience. In his endorsements to the grade of Fellow was the commentary "his engineering work is admirable and his ethical standards of the highest."

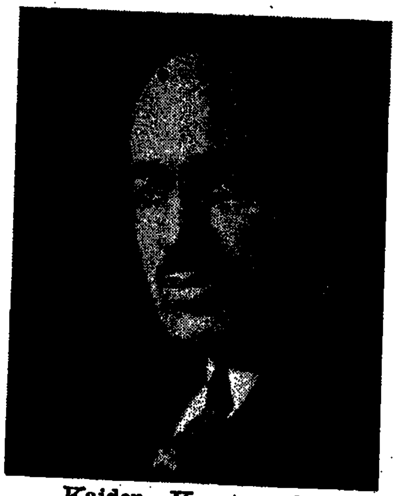
**M. S. Sloan** (A'07, F'30) for the past number of years identified as president, trustee and director of the several companies of the Consolidated Gas Company system, at a recent meeting of the board of directors tendered his resignation. Mr. Sloan's professional career includes a rapid rise from humble beginnings with small southern power companies to early service with the General Electric Company and assistant to the president of the power company at Birmingham, Ala. Thence he went to New Orleans in 1917, returning from that point to become assistant to the president of the New York Edison Company, and finally succeeding Nicholas F. Brady (A'01) as president of the latter company.

R. H. TAPSCOTT (A'18, F'29) who has just been elected a vice-president of the New York Edison Company, became electrical engineer of the Edison company in 1925. His first appointment to office there, following his resignation from the General Electric Company, took place in October 1917, when he was made assistant chief electrical engineer. Mr. Tapscott's activity in committee work, both in the Institute and other societies, has been well known. In the A.I.E.E., he has served as a member of the executive committee of the standards committee for a number of years, on the electrical machinery committee one year, on the power transmission and distribution committee two years, and as chairman of the headquarters committee since 1928; in 1930 he completed a term as chairman of the New York Section. Besides, he has been chairman of the electrical apparatus committee of the National Electric Light Association, a member of its engineering national committee, and as a member of the electrical advisory committee is at present representing the light and power group. Mr. Tapscott has at all times evidenced not only high engineering ability, but a fine sense of professional ideals.

S. N. BOSE (A'13, M'22) who since 1926 has been assistant, and later, deputy chief electrical engineer of the Tata Iron and Steel Company, Ltd., Jamshedpur, India, now is chief electrical engineer of that organization. Notice in the December issue of ELECTRICAL ENGINEERING implied that Mr. Bose had gone to India only recently; the above therefore serves as a correction to the earlier statement. Mr. Bose's New York connection immediately prior to his going to India in 1926 was with the J. G. White Engineering Corporation, his affiliation with the Cazenovia Electric Company, Cazenovia, N. Y., having preceded that with J. G. White.

FREDERICK KRUG (A'17, M'25) vice-president and general manager of the Porto Rico Railway, Light and Power Company, San Juan, has been elected president of the Chamber of Commerce of Porto Rico, affiliated with the Chamber of Commerce of the United States. Mr. Krug is president also of Porto Rico Service, Incorporated, a business man's organization which promotes new industries on the island and exhibitions on the mainland. He is an able member of the governor's insular employment relief committee and of other organizations for civic welfare.

A. W. LEE (A'08) who has been serving the Louisville Gas and Electric Company in the capacity of general superintendent, now has become vice-president in charge of operation to succeed LEWIS STARR STRENG (A'04, F'26) recently deceased. In addition to his new duties as vice-president, Mr. Lee's name has been added to the directorate of the Louisville company. He also has been very active in the field of aviation, and was chairman of a special committee appointed by former Governor Sampson to draft the present state aviation laws.



Kaiden—Keystone Studios

R. H. TAPSCOTT

SANNOSUKE INADA (A'22) one of the most distinguished of Japanese engineers, and one who since 1925 has served as director general of telegraph and telephone engineering of the Teishinsho, or department of communication of Japan, retired on January 11, 1932. He is well known in both American and European communication circles, and his work with the Teishinsho began in 1900 when he was graduated from the College of Tokio Imperial University. Since 1925 he has been also a professor of Waseda University.

HENRY SNYDER (A'24) recently elected president of the New York and Queens Electric Light and Power Company, New York, N. Y., has been interested in the public utilities of Queens ever since 1899 when he assisted in merging two Newtown and two Flushing companies into the New York and Queens Gas and Electric Company. He was president of the New York and Queens Gas Company, resigning to devote all his attention to the development of the electric company, of which he became vice-president several years ago.

SIR OLIVER LODGE, scientist, has been made the recipient of the Faraday Medal presented by the council of the Institution of Electrical Engineers, of Great Britain. He is 80 years old. Sir Oliver's experiments with high frequency oscillations led to the discovery and invention in 1894 of the coherer which contributed to the advancement of wireless telegraphy. The Faraday Medal is awarded not more than once a year for notable scientific or industrial achievement in electrical engineering.

T. S. BURNS (A'31) has been made senior engineer, United States Engineers Office, Huntington, W. Va. Mr. Burns in 1930 was senior hydroelectric engineer, U.S. War Department, in charge of preparation of power report for the Pittsburgh district, and prior to that was estimating engineer with the Pennsylvania Water and Power Company, Baltimore, Md., in charge of estimates on the Safe Harbor project, Susquehanna River.

B. S. BESSESEN (M'27) an associate electrical engineer in the United States Civil Service, who has been acting superintendent of the Muscle Shoals Development, Ala., for the past year, now has received his appointment as superintendent. Mr. Bessesen has held responsible positions in power development projects in the west and from 1922 to 1924 was instructor in electrical engineering at Oregon State College, Corvallis, Ore.

E. S. FITZ (A'16) manager of production and transmission for the past year or so, for the Virginia Electric and Power Company, Richmond, Va., recently was appointed general manager of the electric department for the entire system which serves tidewater Virginia and northeastern North Carolina. His new position gives him charge of distribution as well, and he will continue to make Richmond headquarters.

E. V. SAYLES (A'23, M'30) who has been investigations engineer for the electrical engineering department of Allied Engineers, Inc., Jackson, Mich., now has become general engineer for the Commonwealth and Southern Corporation, in Jackson. Mr. Sayles has served on the underground systems committee of the N.E.L.A. and is a member of the Association of Iron and Steel Electrical Engineers.

A. H. DICKINSON (A'30) formerly research assistant in the department of fuel and gas engineering, Massachusetts Institute of Technology, Cambridge, Mass., has joined the International Business

Machine Corporation, New York, N. Y., as assistant engineer. While a member of the M.I.T. research staff, Mr. Dickinson developed a method for the more accurate calibration of high pressure gas meters.

H. P. Charlesworth (M'22, F'28) vice-president of the Institute and of the Bell Telephone Laboratories, Incorporated, New York, N. Y., and A. W. Berresford (A'94, F'14) past-president of the Institute and managing director of the National Electrical Manufacturers Association, New York, N. Y., are two of the recently elected board of trustees of United Engineering Trustees, Inc.

Daniel W. Mead (A'11, F'13) consulting engineer, New York, N. Y., and Madison, Wis., and professor of hydraulics and sanitary engineering at the University of Wisconsin, at the annual meeting of the American Society of Civil Engineers, held in New York at the Engineering Societies Building, January 20, 1932, was made an honorary member of that organization.

R. W. Sorensen (A'07, F'19) professor of electrical engineering at the California Institute of Technology, Pasadena, Calif., recently was made a member of the board of consulting engineers for the Metropolitan Water District of Southern California. The February issue of Electrical Engineering incorrectly referred to this appointment as one to the board of directors.

J. A. Cook (A'15, F'30) superintendent of the electrical department of the Lynn Gas & Electric Company, Swampscott, Mass., recently was elected chairman of the New England System Operators' Club, and S. C. Jacoby (A'21) superintendent of transmission and distribution, of the Montaup Electric Company, Fall River, Mass., was chosen as the club's secretary.

A. E. Kennelly (A'88, F'13) past-president of the Institute and professor emeritus of electrical engineering, Harvard University and Massachusetts Institute of Technology, Cambridge, Mass., recently was elected an honorary member of the German Elektrotechnischer Verein, and also of the Japanese Institute of Electrical Engineers.

R. M. Garth (A'24) who was distribution engineer for the Knoxville Power and Light Company and associated companies, the Tennessee Public Service Company and Holston River Electric Company, now has been made assistant electrical engineer, Navy Department, Bureau of Yards and Docks, Washington, D. C.

L. S. Horner (A'04) formerly president of Niles-Bement-Pond and Kissel Kinnicutt and Company, New York, N. Y., now has removed to Bridgeport, Connecticut, as vice-president of the Bullard Company. During 1930-31, Mr. Horner was a director of the United States Chamber of Commerce.

L. M. Klauber (F'23) heretofore vice-president and general superintendent of the San Diego Consolidated Gas and Electric Company a subsidiary of the Byllesby Engineering and Management Corporation of Chicago has been chosen vice-president in charge of operation for the San Diego company.

Mabel MacFerran (A'28) who has been technical assistant to the operating engineer of the Southern California Edison Company, Los Angeles, Calif., now has been made assistant electrical engineer of the Metropolitan Water District of Southern California, Los Angeles, Calif.

G. C. WARD

W. J. Miller (A'19, M'26) resigned as dean of engineering and professor of electrical engineering at Texas Technological College to accept the position of professor and head of the department of electrical engineering at the University of North Carolina, effective January 1932.

C. O. Von Dannenberg (A'06, M'30) previously serving the Electric Management and Engineering Corporation, New York, N. Y., as assistant electrical engineer, now has joined the engineering department of the Pennsylvania Central Light and Power Company, Altoona, Pa.

C. G. Jones (A'16, M'18) has left the Westinghouse Electric and Manufacturing Company's head offices at East Pittsburgh, Pa., and his work as inductive heating engineer, to become special engineer for the Youngstown Sheet and Tube Company, Youngstown, Ohio.

E. W. Morris (A'29) has been transferred to the Westinghouse Electric and Manufacturing Company's San Francisco office in the capacity of industrial application engineer. Previously Mr. Morris was with the company's Los Angeles office as general engineer.

C. L. Farrar (A'23) who has been serving as associate professor of electrical engineering, University of Arkansas, Fayetteville, Ark., now is engaged in the electrical engineering department of the school of electrical engineering, University of Oklahoma, Norman, Okla.

C. N. Brubaker (A'19, M'29) in the past managing engineer of the transformer department, General Electric Company, Erie, Pa., has added his name to the roll of the Institute's Pittsfield Section as a result of his recent transfer to the company's Pittsfield office.

F. J. Stevens (A'12, M'27) who has been serving as superintendent of the Parkersburg (W. Va.) plant of the Porcelain Products, Incorporated, recently identified himself with the American Lava Company, Chattanooga, Tenn., as production engineer.

R. B. Tenney, Jr. (A'10) recently joined the Power Cost Engineering and Appraisal Corporation of San Antonio, Tex., as its consulting engineer in Dallas. His previous affiliation was as engineer of the Texas Power and Light Company, also at Dallas.

Alexander Nyman (A'19, M'26) who heretofore has served the Radio Patents Corporation, New York, N. Y., as vice-president, resigned from that position and now is consulting engineer for the Shortwave and Television Corporation, Boston, Mass.

W. C. Woodson (A'22) formerly assistant engineer, meter department of the New York Edison Company, now is assistant engineer in the meter and test department of the United Electric Light and Power Company, Irving Place, New York, N. Y.

E. D. Wood (A'21, M'26) formerly electrical operating engineer for the Louisville Gas and Electric Company, now has been advanced to the office of general superintendent, to succeed A. W. Lee (A'08) who has assumed new executive duties.

F. D. Spofford (A'23) previously traffic engineer for the Wheeling Traction Company, (W. Va.) has been selected assistant to the president of the Blue Ridge Lines, the bus subsidiary of the West Penn Electric Company of Pittsburgh, Pa.

G. C. Ward (M'24) was recently elevated to the rank of senior vice-president of the Southern California Edison Company, Ltd., Los Angeles, Calif., as announced in Electrical Engineering for February 1932, p. 140.

R. J. Clingerman (A'29) has resigned from his work with the Consolidated Gas Electric Light and Power Company of Baltimore, Md., and made new connections in the sales department of the Ochiltree Electric Company at Pittsburgh, Pa.

R. M. Arnold (A'25) who was chief engineer of the radio division of the United Air Cleaner Company, Chicago, Ill., recently was elected vice-president and chief engineer of the United Air Cleaner Corporation of Chicago.

E. F. Venn (A'28) formerly inspector of the maintenance engineering department of the Western Electric Company, Kearny, N. J., has gone to Clewiston, Fla., as assistant engineer for the United States Sugar Corporation.

G. H. Bucher (M'24) assistant general manager of the Westinghouse Electric International Company, New York, N. Y. recently was elected its vice-president and general manager. His headquarters still will be in New York City.

A. L. Woodhouse (A'02) vice-president of the Dixie Power Company, Cedar City, Utah, has removed to Palo Alto and is now vice-president and manager of the Central Mendocino County Power Company, Willits, Calif.

Erland Johnson (A'25) who has been mechanical and electrical engineer for the Detroit Rock Salt Company, Detroit, Mich., now has engaged as superintendent of the Avery Salt Company, Avery Island, La.

W. H. Spencer (A'27) who as assistant secretary to Montreal Light Heat and Power Consolidated has been supervising accident prevention work for this company, now will specialize in safety engineering.

A. J. Duncan (A'09) previously president and general manager for the Fort Worth Power and Light Company, Fort Worth, Texas, has been chosen president of the Texas Electric Service Company of that city.

Melvin Block (A'30) who has been sales engineer of the Wagner Electric Corporation, at Pittsburgh, Pa., now has joined the American Shoe Machinery and Tool Company, St. Louis, Mo., as a salesman.

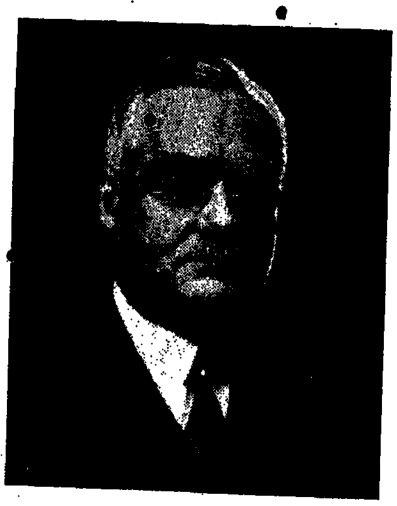
David Nemetz (A'28) who was sales engineer for Electrical Distributors, Vancouver, B. C., Can., recently was made president of the Standard Electric and Radio Company of Vancouver.

M. K. Lock (A'25) who has been serving the firm of Lock, Lang & Austin, Irvington, N. J., as radio engineer, now is chief engineer at the WNJ radio station of Newark, New Jersey.

P. I. Doty (A'30) previously of the industrial department, General Electric Company, Schenectady, N. Y., has been transferred to the company's San Francisco office.

## Obituary

Harold Babbitt Smith (A'91, F'13) junior past-president of the Institute and for 35 years head of the electrical engineering department of Worcester Polytechnic Institute, died February 9, 1932, after an extended illness of almost a year's duration. Doctor Smith was born at Barre, Massachusetts, May 23, 1869. Graduated from Cornell University with the degree of M.E. in E.E. in June 1891; he remained as graduate student until December 1891. In January 1892 he was appointed professor of electrical engineering in charge of the department at the University of Arkansas. Resigning this position later the same year, he became head designer and electrical engineer for the Elektron Manufacturing Company, Springfield, Mass. From September 1893 to June 1896 he was director of the department of electrical engineering at Purdue University. He had held his position as professor of electrical engineering and director of the department at Worcester Polytechnic Institute ever since 1896.


H. B. SMITH

Until 1902 Doctor Smith retained a connection with the Elektron Manufacturing Company as consulting engineer doing consulting work for several other organizations at various times. Since 1905 he had served as a consulting engineer for the Westinghouse Electric and Manufacturing Company of East Pittsburgh, Pa.

In 1904 he was chairman of the international group, jury of awards in electrical engineering at the St. Louis Exposition. During the years 1917-19, he was an associate member of the Naval Consulting Board and consultant of the special board of the Navy on anti-submarine work. He has been a pioneer in the development of high-voltage power transmission systems and equipment, carrying on many researches involving advanced conceptions of dielectric phenomena and stress distribution. He has obtained numerous patents, and has contributed many papers to the transactions of the engineering societies and other technical publications.

Doctor Smith resigned his educational chair at Worcester Polytechnic Institute effective June 1931. As one well known in engineering and education he always has carried forth a multiplicity of duties in these fields. His share in Institute activities has been abundantly represented by service on several of its committees simultaneously, including: law 1920-21; electrophysics and student branches 1920-27; instruments and measurements 1921-22; educational 1922-27; sections 1922-28; Edison Medal 1924-26, 1929-30, 1930-32; research, coordination of Institute activities, and meetings and papers 1924-27; code of principles for professional conduct 1928-29; executive 1929-31; and public policy 1930-31. He was appointed also to the John Fritz Medal board of award for 1929-33, the U.S. national committee of the I.E.C., the Chas. A. Coffin Fellowship and Research Fund committee 1929-30, and the American Engineering Council 1930-31. His other memberships included American Society of Mechanical Engineers (Member), Institution of Electrical Engineers (Great Britain), Society for the Promotion of Engineering Education, American Association for the Advancement of Science, Sigma Xi, and Tau Beta Pi. In 1929 Doctor Smith had two honorary degrees conferred upon him; Doctor of Engineering from Purdue University and Worcester Polytechnic Institute.

Max Toltz (M'22) since 1907 a prominent consulting engineer with offices in St. Paul, Minn., died at his home there January 11, 1932. Mr. Toltz was a native of Koeslin, Germany, where he attended the Koeslin Royal Gymnasium, later winning his civil engineering degree from the Royal Polytechnikum in Berlin, in 1878. A degree of doctor of engineering was conferred upon him in 1924 by the Ramsey Institute of Technology, St. Paul, Minn. After graduation from the Royal Polytechnikum, he served a short apprentice with a Berlin firm and before coming to the United States in 1882 was connected with the Prussian government. In 1889 he became a naturalized American citizen, and devoted the first 25 years spent in the United States to the development of railroads, especially in the northwest. The St. Paul, Minneapolis and Manitoba (later the Great Northern) railway benefited by Mr. Toltz' efforts and energy, his final office with it being engineer in charge of motive power, a position achieved by step-by-step promotions from the position of draftsman. He was consultant in mechanical engineering for the Winnipeg workshops of the Canadian Pacific Railway and also for the Jersey City workshops of the Erie railroad; he was vice-president and general manager for the Manistee and Grand Rapids railroad. During the period 1907-10 the electrification of the Great Northern, the Northern Pacific, Butte, Anaconda & Pacific, and Chicago, Milwaukee & St. Paul railroads deeply engrossed him, as did also work on the ore docks for the Great Northern, Northern Pacific & Soo lines. In 1910 he organized the Toltz Engineering Company of St. Paul, of which he was president, an office which he held also in the successor company, Toltz, King & Day, Inc., formed in 1918. Mr. Toltz retired from active business in 1928. During the World War, from a captaincy which he had held for many years in the Minnesota National Guard, he was given the rank of major in the construction division of the Quartermaster Corps, and in this capacity supervised the construction of General Hospital No. 2, at Fort McHenry, in the city of Baltimore, Md. He was a valued member of the St. Paul Interprofessional Institute, a director of its national board; a vice-president of the American Society of Civil Engineers, a member of the American Railway Master Mechanics Association and of the American Society of Military Engineers. He has served as president of both the Engineering Society of St. Paul and of the Federation of Architectural and Engineering Societies of Minnesota. He was also a member of the Vereines Deutscher Ingenieure. Of the American Society of Mechanical Engineers, which he has served in various capacities since 1904, he has been manager, vice-president, and organizer and first chairman of its St. Paul local section, a member of its executive committee, the 1932 nominating committee, and its committee of awards. The press reports that student loan funds of $15,000 each have been left by Mr. Toltz to the civil and electrical engineering professions, the income from these amounts to be administered by the parent organizations. In 1925 a similar fund was established by him for the mechanical engineers.

Joens Elias Fries (A'04, F'15) chief engineer of the Tennessee Coal, Iron and Railroad Company, Birmingham, Ala., died January 23, 1932, after a prolonged illness. He was a native of Sweden, and was educated there, being graduated from the College of Upsala in 1894 and from the Royal Technical Academy in Stockholm in 1898, with degrees in civil and electrical engineering. In 1900 he engaged with a Stockholm firm manufacturing telephone apparatus; then with the General Swedish Electric Company as estimator for plants of every kind. Following this experience he was appointed superintendent of the Holmia Electric Company of Stockholm, in which capacity he remained until 1903. The next uear he came to America and joined the New York Edison Company, remaining with it briefly before identifying himself with Westinghouse, Church, Kerr and Company for drafting work in connection with the construction of the Long Island railroad electrification. Through the period 1905-07 he was commercial engineer for Allis Chalmers Company, then left for the Canadian General Electric Company, where he became engineer of power plants and power transmission. In 1908 he joined the Crocker-Wheeler Company, spending a year and a half in charge of the estimating department, a like period as industrial engineer, two years as Pacific Coast engineer and the rest of his stay with that company as assistant chief engineer. September 1916 he became chief electrical engineer for the Tennessee Coal, Iron and Railroad Company, a subsidiary of the U.S. Steel Corporation, remaining with these interests up to the time of his death. He was a member of the Association of Iron and Steel Electrical Engineers, the American Society of Mechanical Engineers, the American Association for the Advancement of Science and the American Society for Steel Testing. He also had been a member of the Engineers Club of New York since 1909, and of the Engineers Club of San Francisco since its inception. Mr. Fries was 56 years old at the time of his death.

William Dutton Pomeroy (A'99, M'21) general manager, vice-president and director of the Goulds Pumps, Inc., Seneca Falls, N. Y., died January 6, 1932, after an illness of a year's duration. He had been with the Goulds company since 1908, when he became its general superintendent. His birthplace was Utica, N. Y. (1874). After graduation from Cornell University in 1896, with an M.E. degree, he spent a year as draftsman of the Bossert Electric Construction Company at Utica, leaving it to continue in electrical construction work with the Belt Line Street Railroad Company of that city. He then removed to Akron, Ohio and joined the Akron Electric Manufacturing Company as a draftsman, to be advanced a year later to the office of superintendent and engineer. In this position he remained until 1901, when he was made assistant chief draftsman for the Bullock Electric Manufacturing Company of Cincinnati, Ohio, becoming general superintendent in 1903 and remaining such until 1907. The last year of this period he was also superintendent of the electrical department of the Allis Chalmers Company, Milwaukee, Wis. This was the position from which he went to the Goulds Manufacturing Company, as its general superintendent. Besides his Institute affiliations, Mr. Pomeroy belonged also to the American Society of Mechanical Engineers and the American Institute of Mining and Metallurgical Engineers. By the former he was awarded the Melville Medal for a paper which he prepared jointly with Prof. Herman Diedrichs of Cornell University on the subject of "The Occurrence and Elimination of Surges or Oscillating Pressures in Discharge Lines from Reciprocating Pumps."

Alexander Jay Wurts (A'92, M'92) electrical engineer and a member of the first faculty of Carnegie Institute of Technology, died at his home in Pittsburgh, Pa., January 21, 1932, in the 71st year of his age. His birthplace was Carbondale, Pa. He attended Yale University which in 1883 conferred his Ph.D. upon him. The following year he received his M.E. degree at Stevens Institute of Technology. He then spent two years in the Polytechnikum, Hanover, Germany, and in the fall of 1886 began work with the United States Electric Lighting Company. December of the same year he was placed in charge of the factory of the Julien Electric Company, Camden, N. J., and a year later joined the Westinghouse interests. For eleven years Mr. Wurts was research engineer for George Westinghouse in the development of the Nernst lamp, arresters, etc. His identification with the Westinghouse Electric and Manufacturing Company carried over a period of twenty years; in the course of events he met Andrew Carnegie, and through this acquaintance was elected as the first faculty member of the Carnegie Technical School, which later became known as the Carnegie Institute of Technology. After four years as professor of engineering research, Mr. Wurts gave up teaching, retaining however the chairmanship of the student welfare service of Carnegie Institute. Through the Franklin Institute, Mr. Wurts received the John Scott Medal from the city of Philadelphia for his work with lightning arresters and his discovery of five non-arcing metals. He was a member of the American Philological Society.

**John Robertson Cowley** (A'25, M'29) city electrical engineer, City of Saskatoon, Canada, and past-chairman of the Institute's Saskatchewan Section, died January 16, 1932. He was born in Dundee, Scotland, September 11, 1882, and his early education was obtained at the Harris Academy, in Dundee. His technical training came through two years electrical and mechanical engineering course at the Hariot-Watt College, Edinburgh, and the University of Edinburgh, Scotland. He then served a three-year apprenticeship with an electrical engineering firm in Dundee before joining the Corporation Electricity Works, City of Perth, Scotland. From 1904 to 1907 he was assistant engineer with a municipal tramways company of Scotland, afterwards becoming engineer in charge of distribution for the Clyde Valley Electrical Power Company, Glasgow, Scotland. In 1911 he came to Canada as chief operator for the Canadian Light and Power Company, Montreal. This led to his work with the City of Saskatoon, first as assistant city electrical engineer and then as city electrical engineer, with full charge of generation, distribution, and accounting in the department. His assistantship covered a period of rapid expansion and the results which he obtained through his own leadership were most noteworthy. The city installation included a 10,000-kw. plant and distributing system, in connection with which practically all design and construction devolved upon Mr. Cowley during his term of office, which extended well over a full period of twelve years.

**William H. Fernholz** (M'21) sales engineer of the Electrical Engineer's Equipment Company, at Milwaukee, Wis., died January 25, 1932. He was born in Westphalia, Germany in 1883 and after a full four-year course at a college of engineering in Germany, following earlier training at a technical school in Thuringia, Germany, he came to the United States in 1906 and entered the switchboard department of the Bullock Works, Cincinnati, Ohio. From this first position he changed two years later to drafting work with the Vilter Manufacturing Company, the Johnson Service Company and the Allis-Chalmers Company, respectively, all of Milwaukee; in 1817 he was advanced to the position of chief draftsman of the Federal Rubber Company of Milwaukee, and later in that same year, he became district manager for sales and engineering of the Electrical Equipment Company of Chicago with offices in Milwaukee. While with the Allis-Chalmers Company, Mr. Fernholz did considerable design work in the building of switchboards; also consulting engineering and layout work. He did a valuable amount of important engineering in conjunction with electric power plants, in charge of high-voltage line layout and installations and special design and on construction of switchboards for industrial processes, as well as for the Chinese government. He had been a member of the Institute's Milwaukee Section for some time, and as such took active part in Institute operations.

**William Harrison Bullock** (A'16) for a number of years general engineer of the Westinghouse Electric and Manufacturing Company, Denver, Colo. and past-chairman of the Institute's Denver Section, died January 21, 1932, in his fiftieth year. Mr. Bullock was a graduate of the University of Colorado from which he obtained his B.S. in E.E. in 1904. At the time of his death he was associated with H. S. Sands, consulting engineer in Denver. His service with the Westinghouse company dated from an apprenticeship in 1904, from which time he progressed consecutively through the sales and engineering department to industrial motor application in coal and metal mining and miscellaneous shop applications; also the application of electrical apparatus to agricultural situations to be found in the Rocky Mountain region. Mr. Bullock held membership also in the Electrical League of Colorado.

**Bradley Lyon Child** (A'23) connected with the long lines engineering department of the American Telephone and Telegraph Company, New York, N. Y., as transmission engineer, died January 20, 1932, after a brief illness. He had served this company for 27 years. Born at Meriden, Connecticut, in 1884, Mr. Child came to Brooklyn, N. Y., graduating from Brooklyn Polytechnic Institute with the 1903 class in steam and machine design, and continuing with a special course which he followed by further study on electrical subjects. Since coming to New York, he has always been a resident of Brooklyn. Immediately following his technical studies, he joined the American Telephone and Telegraph Company in New York.

# Local Meetings

## Future Section Meetings

**Akron**

March 8—Electrical Refrigeration and Air Conditioning, by W. M. Timmerman, Gen. Elec. Refrig. Co. Movies. Meeting to be held at Ohio Pwr. Co., Canton, preceded by dinner at Elks Club.

April 12—The Electrical Industry and Some Problems of the Institute, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Movies.

**Baltimore**

March 18—Subject to be announced. Speaker: Capt. Greenlee, Director of Naval Experimental Station.

April 15—Subject to be announced. Speakers from Western Elec. Co.

**Chicago**

March 17—Coordination of Insulation, by F. E. Andrews, Pub. Serv. Co. of Northern Illinois.

**Cleveland**

March 24—Joint meeting with Case Sch. of Applied Science Branch. Speaker: Dr. Dayton C. Miller.

April 21—Electric Refrigeration and Domestic Air Conditioning, by W. M. Timmerman, Gen. Elec. Co.

**Dallas**

March 21—Underground Construction and Cable Developments, by John Oram, Dallas Pwr. & Lt. Co. Meeting to be held in Fort Worth, Texas.

**Detroit-Ann Arbor**

March 15—Vacuum Tubes and Their Application, by E. H. Vedder, Westinghouse Elec. & Mfg. Co.

April 19—Commercial Metering of Electric Energy, by A. S. Albright, Detroit Edison Co.

**Lehigh Valley**

March 18—Research—Industry's Health Insurance, by S. M. Kintner, Westinghouse Elec. & Mfg. Co.

**Louisville**

March 18—Men Who Have Made Electrical Engineering History. Meeting under the auspices of students at Univ. of Louisville. Demonstrations.

April 15—Inspection trip to Bowman Field Airport. Fundamentals of Plane Construction and Flight, by A. W. Lee, Louisville Gas & Elec. Co.

**Lynn**

March 9—Miracles in Nature, by Dr. Pillsbury.

March 16—Local convention. Subject: Recent Developments in the Thomson Research Laboratory, Gen. Elec. Co.

March 26—Inspection trip.

**Pittsburgh**

March 8—Joint meeting with Association of Iron & Steel Elec. Engrs., and Engineers' Soc. of Western Penn.

April 12—Television. Demonstrations. Joint meeting with I.R.E.

**Pittsfield**

March 15—Competitive meeting with Schenectady Section.

**Seattle**

March—Annual joint meeting of Founder societies.

April 19—Joint meeting with Student Branch at Univ. of Washington.

**Spokane**

March 25—Joint meeting with Student Branches at State Col. of Washington and Univ. of Idaho. Papers by local members and students.

April 22—New Developments in Oil Circuit Breakers, by J. F. Spease, Gen. Elec. Co.

**Toledo**

March 18—Inspection trip through Bldgs. 6 and 7 of the Rossford plant of the Libbey-Owens Ford Co.

April 15—Problems in the Design of Large Turbo-Alternators, by S. H. Mortensen, Allis Chalmers Co.; Application of Electricity in Industry, by R. E. Paxton, Toledo Edison Co.

**Vancouver**

March 7—Students' night.

April 4—Switchgear, by W. D. Robertson, Canadian Gen. Elec. Co., Ltd.

# Past Section Meetings

**Akron**

Television, by Dr. J. O. Perrine, Amer. Tel. & Tel. Co. Illus. Dec. 8. Att. 1,600.

X-Ray Inspection of Welds, by Ancel St. John, St. John X-Ray Serv. Corp. Jan. 12. Att. 45.

**Atlanta**

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Joint meeting with A.S.M.E. Sec. Jan. 6. Att. 160.

**Baltimore**

Electrons at Work and at Play, by Dr. Phillips Thomas, Westinghouse Elec. & Mfg. Co. Demonstrations. Dinner. Jan. 15. Att. 975.

**Boston**

Photoelectric Cells, by A. R. Olpin, Bell Tel. Labs. Inc. Demonstrations. Moving pictures describing the life of Thomas A. Edison. Jan. 12. Att. 220.

**Chicago**

The Control of Vibration and Noise in Power Stations, by P. E. Stevens, Byllesby Engg. & Mgmt. Corp. Demonstrations. Joint meeting with the Western Soc. of Engrs. Jan. 7. Att. 150.

**Cincinnati**

Industrial Applications of Photoelectric Cells, by E. H. Vedder, Westinghouse Elec. & Mfg. Co. Illus. Dinner. Dec. 10. Att. 110.

Talking Movies—Historical and Present Day Developments, by F. L. Hunt, Bell Tel. Labs. Inc. Illus. Jan. 14. Att. 330.

**Cleveland**

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Jan. 21. Att. 126.

**Connecticut**

Vacuum Tubes and Some of Their Applications, by J. D. LeVan, Ratheon Co., F. G. Kelly, Engg. and Research Corp., and H. Raymond, Stanley Works. Demonstrations. Jan. 19. Att. 142.

**Dallas**

Joint meeting with Southern Methodist Univ. Branch. Following papers presented by students: Thyratron Tubes, by J. V. Melton; Deion Circuit Breaker, by J. W. Emery; Recent Developments in Radio Receiving Tubes, by J. N. Walker and D. Ramsey. Jan. 18. Att. 60.

**Denver**

Four Films—"Earl Carroll in the House of Magic," "Mica Insulation by Machine Methods," "Mazda Lamps Preferred," and "The Electric Ship." Dinner. Jan. 15. Att. 70.

**Detroit-Ann Arbor**

The Business of Being a Woman, by Miss S. M. Sheridan, Detroit Edison Co. Dinner, dancing, and bridge. Jan. 19. Att. 91.

**Erie**

The Theories of Ether Waves and Radiation, by W. E. Forsythe, Gen. Elec. Co. Illus. Jan. 19. Att. 125.

**Houston**

Joint meeting with Rice Inst. and A. & M. Col. of Texas Branches. First and second prizes awarded to C. K. Beyette, Rice Inst., and C. C. Nash, A. & M. Col., respectively. Jan. 16. Att. 86.

**Indianapolis-Lafayette**

Arc Welded Steel Houses, by R. G. Eaglesfield, Lincoln Elec. Co. Illus. Dinner. Jan. 15. Att. 30.

**Ithaca**

The Present Economic Situation, by Dean Dexter S. Kimball, Cornell Univ. Joint meeting with Cornell Univ. Branch. Dec. 11. Att. 60.

**Los Angeles**

Aerial Map Making, by L. T. Eliel, Fairchild Aerial Surveys, Inc.; Airport Signaling, by Capt. E. Deeds, Commanding Officer, 478th Pursuit Squad. Dinner. Jan. 12. Att. 250.

**Louisville**

Practical Application of Light Sensitive Cells, by E. H. Vedder, Westinghouse Elec. & Mfg. Co. Demonstrated. Jan. 22. Att. 350.

**Lynn**

Mining of Diamonds in Africa, by Dr. Palache. Inspection of the mineral and glass flower exhibits at the Peabody Museum, Harvard Univ. Jan. 16. Att. 150.

Adventures in Science, by E. L. Manning, Gen. Elec. Co. Jan. 8. Att. 850.

Gas Compression and Application of General Electric Compressors, by R. P. Mansfield, Gen. Elec. Co. S. N. F. Hedman described the various types of compressors manufactured by Gen. Elec. Co. Superchargers, by S. A. Moss, Gen. Elec. Co. Jan. 20. Att. 175.

**Madison**

The Industrial Application of Electron Tubes, by L. L. Ludwigsen, Gen. Elec. Co. Discussion. Dinner. Jan. 20. Att. 47.

**Memphis**

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Jan. 8. Att. 65.

**Mexico**

B. E. Arias described the electrically operated bridge spanning the Panuco River at Tamos on the lines of the National Ry. of Mexico. Illus. Jan. 19. Att. 40.

**Milwaukee**

What is Best for the Engineer, by E. S. Nethercut, director and secy. Western Soc. of Engrs. Joint meeting with Western Soc. of Engrs. Dinner. Dec. 16. Att. 250.

The Milwaukee Vocational School—Its Scope and Object, by R. L. Cooley, director. Moving pictures. Dinner. Jan. 20. Att. 125.

**Minnesota**

Informal talks by Prof. J. M. Bryant, K. J. Mertz, R. Reinbold, O. Gaarden, E. H. Hagensick, E. J. LeBlond, and A. C. Willard. Inspection trip through the Northern States Pwr. Co. bldg. Refreshments. Jan. 27. Att. 40.

**Niagara Frontier**

Communication in the Aviation Industry, by E. I. Pratt, Western Elec. Co. Illus. Jan. 15. Att. 175.

**Pittsfield**

Capturing Wild Animals, by Frank Buck. Dinner. Dec. 1. Att. 1,375.

Electrical Instruments as an Aid to Aviation, by C. F. Green, Gen. Elec. Co. Dinner. Dec. 15. Att. 220.

Soviet Russia and Eastern Europe, by Wm. C. White. Dinner. Jan. 5. Att. 1,100.

Foreign Power Systems, by Philip Sporn, Amer. Gas & Elec. Co. Illus. Dinner. Jan. 19. Att. 170.

Jungle Gods, by Capt. Carl Von Hoffman. Feb. 2. Att. 1,350.

**Portland**

The Men and the System Behind the Five-Year Plan, by G. W. Freide. Jan. 19. Att. 143.

**Providence**

Synchronous Driven Electric Clocks and System Regulation from Their Use, by H. E. Warren, Warren Telechron Co. Demonstrations. Jan. 12. Att. 50.

**St. Louis**

A New Type of Silent Fan, by Prof. W. L. Upson, Washington Univ. Demonstrations. Jan. 20. Att. 114.

**San Antonio**

The Eagle Pass Hydro Plant, by G. L. Dowell, Central Pwr. & Lt. Co. Jan. 18. Att. 32.

**San Francisco**

New and Interesting Developments in the Electrical Field, by A. W. Copley, Westinghouse Elec. & Mfg. Co., and W. C. Smith, Gen. Elec. Co. Illus. Michael Faraday, by Wm. Hudgins, student, Univ. of Calif. Dinner. Jan. 22. Att. 112.

**Sharon**

A Beam of Light, by J. M. Kelch, Gen. Elec. Co. Jan. 19. Att. 220.

**Southern Virginia**

Business meeting. Election of officers as follows: Cecil Gray, chairman; E. L. Lockwood, Secy.-Treas.; L. W. Webb and W. R. McCann, members, exec. committee. Electrical Pioneering in Brazil, by W. R. Worth. Dinner. Jan. 21. Att. 10.

**Spokane**

Teletypewriters—The Modern Method of Communication, by R. J. Morgan, Pacific Tel. & Tel. Co., assisted by W. M. Allen, Home Tel. & Tel. Co. Jan. 22. Att. 91.

**Springfield**

Thyratrons, by R. H. Rogers, Gen. Elec. Co. Illus. Nov. 9. Att. 80.

Adventures in Science, by E. L. Manning, Gen. Elec. Co. Demonstrated. Joint meeting with Engg. Soc. of Western Mass. and A.S.M.E. Sec. Dec. 11. Att. 3,000.

**Toledo**

Maintenance of Electrical Equipment, by W. E. Drager, Bunting Brass & Bronze Co.; Safety from the Inspector's Viewpoint, by Frank Lucas; Trolley Coaches or Buses, by

R. H. Dalgleish, Jr., Westinghouse Elec. & Mfg. Co. Moving pictures describing trolley coaches in Chicago and Salt Lake City. Jan. 15. Att. 75.

Lt. Alford J. Williams, Jr., aviation engr., spoke on the present situation in the Far East and the part played by aircraft. Feb. 4. Att. 700.

**Toronto**

Proposed Legislation for Licensing of Engineers, by H. Hellmuth, Assn. of Prof. Engrs. of Ontario. Jan. 22. Att. 104.

**Utah**

Microphones, by Prof. O. C. Haycock, Univ. of Utah; Symon's Crusher Installation at Garfield, by V. J. Del Duke; Unusual Meter Installations, by F. O. Weld, both of the Utah Pwr. & Lt. Co. Jan. 11. Att. 37.

**Vancouver**

National and International Aspects of the Gold Standard, by Prof. H. F. Angus, Univ. of British Columbia. Joint meeting with Engg. Inst. of Canada. Jan. 4. Att. 75.

Magnetic Phenomena in a Two-Phase Static Balancer, by Prof. E. G. Cullwick, Univ. of British Columbia. Feb. 1. Att. 30.

**Washington**

Engineering Aspects of Marine Transportation, by F. V. Smith, Gen. Elec. Co. Dinner. Jan. 12. Att. 85.

**Worcester**

Industrial Lighting, by Alfred Paulus, Westinghouse Lamp Co. Jan. 7. Att. 35.

## Past Branch Meetings

**University of Akron**

Biography of Charles P. Steinmetz, by R. A. Ries, student; Modern Electric Elevators, by P. S. Bechtol, student. Jan. 13. Att. 11.

**University of Arizona**

Film—"The Conowingo Project." Jan. 8. Att. 42.

Electric Furnace, by J. W. Newman, student; Lightning, by T. S. Henderson, student. Jan. 15. Att. 6.

**University of Arkansas**

Construction and Use, Quality and Advantages of Aluminum Cables for Electrical Purposes, by C. B. Owen, The Aluminum Co. of America. Jan. 14. Att. 27.

Electric Elevators, by W. J. Pruett, student; Electric Furnaces, by R. B. Stone, student. Jan. 20. Att. 23.

**University of British Columbia**

Power Distribution in the British Isles, by C. E. G. Brown, student; Armature Reaction in Tap Wound D. C. Machines, by D. S. Smith, student. Films—"Hydroelectric Power" and "Oil Circuit Breakers." Jan. 11. Att. 19.

Dust Precipitation by Electricity, by J. D. Mitchell, student; Radio Broadcast Control, by W. B. Smith, student; Photoelectric Cells, by H. C. Freedman, student. Jan. 26. Att. 16.

**Bucknell University**

Steam Turbine Generator Sets, by W. E. Hall, student. Dec. 9. Att. 10.

Modernization of Industries, by I. Z. Hertzler, Hertzler & Zook Co. Jan. 13. Att. 36.

**California Institute of Technology**

Carl Hines and J. M. Gaylord, Metropolitan Water District, discussed the construction and electrical features of the Metropolitan aqueduct. Jan. 21. Att. 38.

Film—"New Dollar Liner, President Coolidge." Jan. 29. Att. 130.

**University of California**

The Application of X-Rays to Speech Analysis, by Prof. R. T. Holbrook. Refreshments. Jan. 28. Att. 76.

**Case Sch. of App. Science**

Experimenting with High Frequency Oscillators, by C. L. Harvey, student; A Thesis on the Power Factor of Condensers, by R. W. Schindler, student. Dinner. Jan. 14. Att. 21.

**Catholic University of America**

Electricity—Its History and Growth, by Dr. Valade. Refreshments. Jan. 13. Att. 29.

**University of Cincinnati**

Recent Developments in Electro-Chemistry, by Prof. E. C. Farnau. Refreshments. Jan. 20. Att. 45.

**Clarkson College of Technology**

Inspection trip to the Sugar Island, Hannawa Falls, Brown's Bridge, and Higley plants on the Racquette River. Oct. 26. Att. 27.

Inspection trip through the plant of the Aluminum Co. of America. Nov. 11. Att. 21.

**Clemson Agricultural College**

X-Rays and Their Applications, by H. L. Wyant, student; Electrification of the Airship Akron, by W. F. Tribble, student; Practises Used by the American Cast Iron Pipe Co., by W. M. Thames, student; Inspection of Boilers by X-Rays, by L. C. Black, student. Jan. 28. Att. 15.

**Colorado Agricultural College**

Films—"Life of Edison and Invention of Incandescent Lamp," and "Edison Visits General Electric Mazda Plant and Research Laboratories." Jan. 11. Att. 22.

**University of Colorado**

Discussion. Jan. 13. Att. 33.

The Teletypewriter, by Mr. Carr, Bell Tel. Co. Demonstrated. Jan. 27. Att. 106.

**University of Denver**

Business meeting. Jan. 18. Att. 13.

Film—"The Single Ridge," Feb. 2. Att. 55.

Inspection trip through the Amer. Tel. & Tel. Co. bldg. Feb. 5. Att. 56.

**University of Detroit**

Ultraviolet Radiation, by Mr. Garwood, Gen. Elec. Co. Films—"Vacuum Tube Synchronizing Equipment," and "Hydroelectric Power." Jan. 13. Att. 50.

The Latest Developments in Electricity, by W. A. Furst, Westinghouse Elec. & Mfg. Co. Moving pictures. Feb. 3. Att. 18.

**Drexel Institute**

Experiments on One-Quarter Million Volt Lightning Machine and Cathode Ray Oscillograph, by I. Eldridge, Elec. Serv. & Supply Co. Demonstrations. Jan. 20. Att. 35.

**Duke University**

Stanley Flack, chairman, gave a summary of the activities at the Conference on Student Activities, District No. 4, held at the Univ. of Florida. Jan. 14. Att. 23.

Stanley Flack and Mr. Debrunny, students, gave talks on radio circuits. Feb. 4. Att. 23.

**University of Florida**

Film—"The Single Ridge." Jan. 20. Att. 43.

**Georgia School of Technology**

Talk by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Joint meeting with A.S.M.E. Branch. Jan. 7. Att. 160.

**Harvard University**

Inspection trip to the short-wave and television laboratories, Boston. Jan. 12. Att. 37.

**University of Illinois**

Joint meeting with the Urbana Section. Papers presented by students as follows: The Electron Tube in the Modern World, by F. M. Deerhake; Electrification of Railways in India, by R. D. Varma; Television, by D. L. Pettit; The Thermocouple and Its Application to Temperature Measurements of Electrical Apparatus, by B. Figlewski. Jan. 6. Att. 31.

**Iowa State College**

Three Power Locomotives, by John Cross, student; The Root of Three, by Mr. Proctor, student. Jan. 20. Att. 79.

**University of Iowa**

Michael Faraday, by George Koval, student. Dec. 9. Att. 40.

Military Aviation, by Capt. Hide, U.S. Air Corps. Moving pictures. Dec. 16. Att. 142.

Modern Illumination, by Mr. Cleaver, Westinghouse Lamp Co. Joint meeting with A.S.M.E. Branch. Jan. 6. Att. 100.

**Kansas State College**

Film—"The Busy Body." Talks by four students. Dec. 17. Att. 38. Afternoon meeting. Program repeated same evening. Att. 65.

Television, by Mr. Higgenbottom. Film—"Pillars of Salt." Jan. 7. Att. 62. Program repeated same evening. Att. 40.

**Lafayette College**

Hydrographic Surveying, by A. M. Tomkins, student; Theory of Vacuum Tubes, by W. G. McLean, student. Jan. 21. Att. 21.

**Lehigh University**

Experiences on R-17 Test, by Carl W. Banks, student; Industrial Applications of Electricity, by D. M. Petty, student. Refreshments. Jan. 8. Att. 35.

**Lewis Institute**

Hydraulic Engineering, by G. Pfau, Allis-Chalmers Co. Illus. Jan. 22. Att. 160.

My Summer in Europe, by D. E. Dunne, student. Jan. 28. Att. 85.

**Louisiana State University**

Discussion. Dec. 19. Att. 22.

Economic Problems of Public Utilities, by R. M. Dreyfus, student; Rectification, by G. De La Matyr, student. Jan. 15. Att. 18.

**University of Louisville**

Discussion. Jan. 13. Att. 14.

**University of Maine**

The Business Side of the Public Utility, by R. T. Haskell, Bangor Hydroelectric Co. Jan. 14. Att. 32.

**Marquette University**

Demonstrations of various chemical experiments. Moving pictures. Joint meeting with A.S.M.E., A.S.C.E., and A.S.Ch.E. Branches. Dec. 10. Att. 250.

Discussion. Jan. 7. Att. 20.

**Michigan Col. of Mining and Technology**

The Life of Charles P. Steinmetz, by F. J. Komerska; Electrochemistry, by Prof. C. M. Carson. Jan. 14. Att. 22.

Electricity in Mining Engineering, by Prof. C. H. Baxter. Film—"King of the Rails." Jan. 28. Att. 25.

**Michigan State College**

Discussion. Feb. 2. Att. 16.

**University of Michigan**

Railroad Electrification, by H. L. Andrews, Gen. Elec. Co. Jan. 19. Att. 98.

**School of Engineering of Milwaukee**

The Newer Developments in the Telephone Industry, by George French, Wisconsin Tel. Co. Illus. Jan. 14. Att. 248.

**University of Minnesota**

Electrical Radiation Energy as Applied in Medical Practise, by Paul Luckenback, Gen. Elec. Co. Illus. General Electric Student Shop Course, by F. Suhr. Films—"Automatic Substations," and "Electric Trolley Buses." Jan. 21. Att. 95.

**Missouri School of Mines and Metallurgy**

Short talks by eight students. Jan. 14. Att. 9.

Electrical Construction Practise, by Wm. B. Fisher, Union Elec. Lt. & Pwr. Co. Jan. 27. Att. 40.

**University of Missouri**

Atoms and Electrons, by Dr. H. D. Arnold, Bell Tel. Labs. Inc. Joint meeting with Sigma Xi. Nov. 11. Att. 153.

Principles Governing the Action of the Photoelectric Cell, by N. R. Beers, student; Commercial Uses of the Photoelectric Cell, by De Laporte Johnson, student. Dec. 16. Att. 26.

Prospecting by Radio, by C. L. Lewis and A. E. Coffman, students. Jan. 13. Att. 20.

**University of Montana**

Papers by students: A New Warning Beacon, taken from *Electric Journal*, presented by Lewis Ambrose; Electrical South, by H. Archibald; Frequency Converter Sets Installed Outdoors, taken from *Electrical World*, presented by Harry Beck; Helical Grooves in Slip-Rings and Commutators, taken from Electrical Engineering, presented by E. Blanchard; Water Power Resources of Montana, by Arthur Buckley. Jan. 7. Att. 104.

A Weather Station on Wheels, taken from *Tycos*, presented by Edgar Dolum; The Milwaukee Electrical Shops, taken from *Electric Traction*, presented by Leonard Estey; Communication in the New Waldorf-Astoria, by Edward Fisher; Nerve Injuries from Electric Shocks, taken from Electrical Engineering, by Wesley Funk; Arc Welding Aluminum, by Vern Hankins; Telephone Apparatus for the Hard of Hearing, taken from *Bell Laboratory Record*, presented by Curtis Hanson. Jan. 14. Att. 100.

**University of Nebraska**

What an Engineering Student Should Get Out of a College Course, by Dean O. J. Ferguson. Election of officers: Walter M. Ely, chairman; John Hutchings, vice-chairman; A. L. Coffin, secy.-treas. Dinner. Jan. 13. Att. 35.

Inspection trip through the Northwestern Bell Tel. Co. bldg. Feb. 3. Att. 32.

**Newark College of Engineering**

Magnetic Testing, by Mr. Morningstern, Western Elec. Co.; Oil Filled Cables, by I. Mirkin, student. Jan. 25. Att. 18.

**College of the City of New York**

Election of officers: Robert G. Herzog, chairman; John Ragazzini, secretary; Jean Marcus, vice-chairman; Charles Grossfeld, treas. Jan. 7. Att. 16.

The Electron Tube—A New Tool for the Electrical Engineer, by O. H. Caldwell, editor *Electronics*. Illus. Feb. 11. Att. 84.

**New York University**

A-C. Arc Welding, by L. S. Lindorf, student; Thyratron Tubes, by G. M. Heckel, student. Feb. 9. Att. 13.

**North Carolina State College**

Smoker and discussion of Branch problems. Jan. 12. Att. 42.

**University of North Carolina**

The Field for Electrical Engineers, by Prof. W. J. Miller. Jan. 14. Att. 25.

**North Dakota State College**

Iron Ore Mining, by James Samways, student. Film—"Arteries of Industry." Jan. 27. Att. 40.

**University of North Dakota**

Fifty-Kw. Transmitter of WTIC, by Wm. Denk, student; Speed Torque Curves of Induction Motors, by A. Eynon, student. Jan. 13. Att. 15.

Mercury Arc Rectifiers, by Leland Hauck, student. Luncheon. Jan. 20. Att. 15.

The Mathematical Development of Fourier's Theory, by Prof. H. F. Rice, counselor. Election of officers: A. J. Redmann, chairman; C. R. Moore, vice-chairman; G. I. Anderson, secy.-treas. Feb. 3. Att. 15.

**Northeastern University**

Lightning, by Prof. C. L. Dawes, Harvard Univ. Refreshments. Jan. 13. Att. 112.

**University of Notre Dame**

Mathematics as Taught in German Universities and Secondary Schools, by Prof. P. G. Menge; Illumination, by Joseph Bean, student; The Robot, Our Electrical Superman, by Wm. Fromm, Jr., student; Life and Achievements of Thomas Edison, by John Scanlon, student. Illus. Dec. 14. Att. 52.

Weather and Climate, by Prof. D. Hull; Electrification of Coal Mines, by A. Neal, student; Electrification of Railroads, by A. Hiegel, student. John Scanlon presented the engg. digest. Jan. 18. Att. 62.

**Ohio Northern University**

Various Types of Electric Railways and Costs of Construction, by Donald Highlands, student. Nov. 19. Att. 20.

**Ohio State University**

Non-Technical Aspects in Engineering, by Mr. Bibber. Charles B. Sloan elected chairman. Jan. 14. Att. 28.

**Oklahoma A. & M. College**

Store and Show Window Lighting, by T. Hutchinson, student. Jan. 11. Att. 24.

**University of Oklahoma**

Noise Induction, by E. V. Jennings, Bell Tel. Co. and C. E. Bathe, Okla. Gas & Elec. Co. Jan. 13. Att. 98.

**Oregon State College**

Development and Application of Loading Coils to Telephone Circuits, by E. MacCracken, student; Choosing a Communication System for a Power Co., by J. B. Manning, student. Jan. 18. Att. 42.

Development and Use of the Vacuum Tube Voltmeter, by K. Eldredge, student. W. Hynes, student, described his summer work on the Ariel Dam. Feb. 3. Att. 21.

**Pennsylvania State College**

Grinding of Quartz Crystals for Use in Radio Work, by P. G. Cooper, student. Talk by R. K. McClintock, student. Jan. 13. Att. 29.

**University of Pittsburgh**

Mr. Hays, Westinghouse Elec. & Mfg. Co., described his travels through Central and South America. Dec. 1. Att. 87.

Electrolytic Condensers, by E. S. Drobick, student; Modern Aspects of Rigid Airships, by K. Hartwig, student. Dec. 3. Att. 124.

History of the Telephone and Toll System, by J. A. Cadwallader, Bell Tel. Co. of Pa. Dec. 10. Att. 122.

Discrepancies in Our Electrical Units, by H. E. Evans, student; Nela Park Works, Gen. Elec. Co., by F. E. Sauerburger, student. Jan. 7. Att. 123.

**Pratt Institute**

Constructional Details of Electric Meters, by A. R. Warrell, student; Oscillations in Vacuum Tubes, by H. Harrison, student. Jan. 11. Att. 28.

**Purdue University**

Surge Generators, by T. T. Woodson, student; Radio Broadcasts, by R. R. Brunner, student. Nov. 3. Att. 64.

The Thyratron Tube, by Dr. Nottingham, M.I.T. Nov. 24. Att. 250.

Film—"The Single Ridge." Dec. 8. Att. 33.

**Rhode Island State College**

M. J. Carr, student, gave a résumé of the principal engineering developments during the past year. Jan. 21. Att. 12.

Construction and Purpose of the Poulsen Arc, by Messrs. Porter and Andrews, students; Theory and Application of the Non-Linear Circuit, by Leon Breault, student. Jan. 28. Att. 28.

**Rose Polytechnic Institute**

Oil Electric Locomotives, by J. T. Jones, student; Hydrogen, a Cooling Medium for Large Machines, by C. N. McGillivray, student; Dibutyl Phthalate, by J. Neimi and J. Montgomery, students. Jan. 13. Att. 36.

**University of Santa Clara**

Film—"Rubber." Joint meeting with A.S.M.E. Branch. Jan. 13. Att. 100.

Recent Developments in the Field of Electrical Engineering, by W. C. Smith, Gen. Elec. Co. Joint meeting with A.S.M.E. Branch. Jan. 21. Att. 93.

The Sunnyvale Airbase, by Wendell Thomas. Joint meeting with A.S.M.E. Branch. Jan. 28. Att. 87.

**University of South Carolina**

Business meeting. Jan. 11. Att. 14.

Boulder Dam, by H. G. Smith, student; Construction of Voltage Divider, by J. A. Kaigler, student. Jan. 14. Att. 34.

**South Dakota State School of Mines**

Annual frolic. Jan. 15. Att. 65.

**University of Southern California**

Discussion. Jan. 6. Att. 18.

Business meeting. Jan. 13. Att. 16.

Election of officers: M. C. Marshall, chairman; L. H. Bayha, vice-chairman; R. R. Moore, secy.; M. B. Gentillon, treas. Jan. 20. Att. 18.

**Stevens Institute of Technology**

Future Possibilities of the Diesel Engine, by Prof. E. H. Fezandie. Jan. 15. Att. 46.

**Syracuse University**

Frequency Converters, by O. H. Peters, student; Keokuk Hydroelectric Development, by M. Collins, student. Jan. 8. Att. 21.

Oil Filled Cables, by A. B. Rowley and L. M. Keenan, students. Jan. 15. Att. 21.

Harmonics in Transformers, by H. Francis, student; Automatic Pilot, by Wm. Bangs, student. Jan. 22. Att. 21.

**Texas A. & M. College**

A Study of the Peculiarities of Telephone Rates, by J. W. Bouton, student; Designs of a Vacuum Tube Voltmeter, by C. C. Nash, student; Potential Instrument Transformers, by C. W. Bruns, student; Instrument Current Transformers, by R. L. Suggs, student; Steam Turbines in Power Generation, by O. T. Halliday, student; Auto-Transformers, by J. E. Hurley, student. Jan. 14. Att. 50.

**Texas Technological College**

Gaseous Tube Lighting, by C. T. Hatchett, student; Service and Service Organization of Large Communication Companies, by Evans Riley, student. Jan. 13. Att. 12.

Prof. L. S. Grandy elected counselor for the remainder of the year ending July 31.

**University of Texas**

Radio Airway Beacons, by Prof. R. Cranberry. Election of officers: Herman F. Barsun, chairman; E. Neuenschwander, vice-pres.; Wm. Garrett, secy.-treas.; Lowell Baker, corresponding secy. Jan. 14. Att. 25.

**University of Utah**

Football and Other Athletics in Their Relation to Life, by I. J. Armstrong. Jan. 14. Att. 57.

**University of Vermont**

Prof. L. P. Dickinson, counselor, gave a description of the winter convention of the Institute. Feb. 1. Att. 20.

**Virginia Military Institute**

Tests in the Westinghouse Laboratory, by C. W. Horseman, student; Transportation on Land, Sea, and Air, by W. B. Gibbs, student; The Gain in Flight Safety, by H. L. Woodson, student; Electricity in Modern Medicine, by J. T. Brugh, student. Feb. 9. Att. 52.

**Virginia Polytechnic Institute**

Examination and Certification of Engineers, by E. E. Barnard. Jan. 28. Att. 176.

Electric Drive for Power Plant Auxiliaries, by L. H. Morris, student; The Weather Report Instruments of the Akron, by W. H. Johnson, student. Feb. 4. Att. 42.

**University of Virginia**

Beauharnois Harnesses St. Lawrence for 2,000,000 H.P., by G. K. Carter, student; The Electrical Equipment Installed in the U.S.S. Akron, by R. W. Talley, student. Jan. 22. Att. 13.

**University of Washington**

Telephone Transmission, by J. R. Tolmie, Pacific Tel. & Tel. Co. Illus. Jan. 7. Att. 27.

Television, by T. M. Libby, Pacific Tel. & Tel. Co. Jan. 14. Att. 38.

Film—"Evolution of Power." Jan. 28. Att. 30.

**Worcester Polytechnic Institute**

Discussion. Jan. 25. Att. 25.

**University of Wyoming**

Electric Welding, by F. Wegher, student. Jan. 12. Att. 10.

Modern Telephone Practise, by L. R. Probst, Mountain States Tel. & Tel. Co. Neil H. Sanders, pres.; F. W. Wegher, vice-pres.; E. Cogswell, secy.-treas. Feb. 2. Att. 12.

## Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Araldsen, O., Westinghouse Club, Wilkinsburg, Pa.
Beck, B.O., 6165 Winthrop Ave., Chicago, Ill.
Berry, Wayne J., c/o Genl. Elec. Co., Schenectady, N.Y.
Bugg, Vernon, 736 Transportation Bldg., Washington, D.C.
Fay, John L., Genl. Del., Philadelphia, Pa.
Goldsman, Jacob L., 64 Priory Rd., Hampstead, London, Eng.
Keilien, S., 52 St. Francis St., Medford, Mass.
Kirby, F.M., 369 Lexington Ave., New York, N.Y.
Palit, Hari-Charan, 151 Ganesh Mohal, Benares City, India.
Rogge, C.A., Consumers Pwr. Bldg., Jackson, Mich.
Shapiro, Max, 757 Franklin Ave., Wilkinsburg, Pa.
Thomas, Earl Mead, Intl. Genl. Elec. Co., Schenectady, N.Y.
Titland, Trygve T., 1019 Stanton Ave., Elizabeth, N.J.
Van Der Dussen, John, 114 Gotham Ave., Gerrittsen Beach, B'klyn, N.Y.

# Employment Notes

## Of the Engineering Societies Employment Service

## Men Available

### Junior Engineers

E.E. GRAD. 1931, 24, single. 4 yr. experience in machine shop, foundry, and assembly dept. 1 yr. drafting for industrial concern. Desires position with mfg. concern or utility company. Available at once. Location, immaterial. D-311.

DISTRIBUTION ENGR., E.E. Grad. 1931, 20. Mich. State Col., single. 4 months' experience as distribution engr. for utility. Ambitious, hard worker, not afraid of responsibility. Best of references, available at once. D-323.

E.E. GRAD., cooperative college, single, 23, Protestant. Considerable machine shop and construction experience, automotive practise; 2 yr. in G.E. test course, control equip. Seeking opportunity in engg. design and development. Location and salary secondary to opportunity. Available short notice. D-36.

E.E. GRAD. 1931, 22, single, Penn. State Col., available on reasonable notice. 1 yr. experience with silk-mill equipment, 3 months in transmission dept. of utility, 2 semesters motor tests in college. Desires position with utility, engg. or mfg. company. Location, U.S., East preferred. C-9850.

E.E. GRAD. 1928, 25, single. 2½ yr. grad. study. Some experience in geophysical exploration. Available now. Location, immaterial. D-359.

YOUNG ENGR. with exceptional experience, B.S. 1928, M.S. 1930 from Worcester P.I., single, 25. 2 yr. as high voltage research asst. to recent A.I.E.E. pres. 18 months as transformer design engr. for Westinghouse. Will prove valuable to mfr., utility, or construction firm. Location, immaterial. Available now. D-319.

E.E. GRAD. Experience on multiple-unit cars. 18 months G.E. test. Automatic switchboards, motors and generators, power transformers, mercury arc rectifiers. Asst. head of rectifier test. Desires position with pwr., mfg. or ry. company. D-357.

E.E. GRAD., 1929, single, 23. 15 months as student engr. on G.E. test. Some test, drafting, and switchboard construction experience before graduation. Interested in position with a firm doing consulting or construction work or with utility or mfr. Available at once. Location anywhere in U.S., New Eng. preferred. C-8028.

E.E. GRAD., 1931, Clemson Agri. Col., 25, single. Desires work with utility, mfg. concern or construction corporation. Available immediately. Location, immaterial. D-400.

RECENT GRAD., '28, lab. experience including motor and generator design and research, drafting, oscillograph operation, breakdown and iron core-loss tests. Experience in testing industrial control equip. and telephone equip. Available, immediately. C-6611.

E.E. GRAD., 1930, 23, single. 15 months on G.E. test of railway equipment, rectifiers, industrial apparatus, industrial control, and refrigeration development. Desires position with utility or mfg. concern. Available at once. D-409.

E.E. GRAD., 1929, 23, single. M.S. from M.I.T., 1931; 20 months G.E. test course. At present teaching in E.E. dept. of leading tech. col. Desires instructorship in E.E. Available in June. Location, immaterial. C-9462.

E.E. GRAD., 1929, 25, single. M.S. '31 from M.I.T. 1 yr. G.E. test; 4 summers gen. maintenance work with telephone company. Available at once. Will go anywhere, to any position for which qualified. Salary secondary. D-175.

E.E. GRAD., 1930, 25 years of age, G.E. test experience, and about 2 yr. of wiring and repair work. Salary second to a position. Location, immaterial. D-433.

E.E. GRAD., Purdue, 1931, single, 24. 7 months in training course of a large utility company. Experienced in stenographic and secretarial work. Desires position with a future in mfg. concern or utility company. Available at once. Location, immaterial. D-437.

1931 E.E. GRAD., 23, single. High scholastic record (Tau Beta Pi). Type of work and salary secondary. Will go anywhere. Available at once. D-438.

E.E. GRAD., 1931, Worcester P.I., 22, single, member Sigma Xi, desires connection with utility concern, industry, or with teaching, also interested in drafting. Location, immaterial. Available at once. D-228.

E.E. GRAD., 1930, Georgia Tech. cooperative plan. Westinghouse lighting courses. Cooperative work, alternate months, 5 yr. large power company in substation maintenance and office engg. Thorough experience, equip. of utility and industrial customers. Now employed installing and servicing automatic stokers, heat controls, etc. Excellent references. Perfect health. Location, immaterial. C-7847.

E.E. GRAD., 1931, M.I.T. American, 25, single. Desires position with mfg. or utility company. Business environment qualifies him for sales work also. Eastern states preferred, but not essential. Available immediately. D-110.

1931 E.E. GRAD., Lehigh Univ., 23, single. Summer experience in test dept. of utility. Location, immaterial. Available immediately. D-447.

1931 E.E. GRAD., Lehigh Univ., 23, single. 12 months' experience with utility in construction. Ambitious and reliable. Available now for position of any elec. nature. Location, immaterial. D-451.

### Construction

ASSOC. E.E., 34, married, technical education, desires position with utility. Exceptional ability in underground transmission and distribution systems. 1 yr. central station construction experience. Location, immaterial. Available on short notice. D-278.

### Design and Development

ELEC. AND MECH. DESIGN ENGR., 37, married. Pratt Inst. night sch. grad. I.E. course. 12 yr. experience design of generating and substations; industrial layout of factories, warehouses and offices. Practical experience on maintenance of elec. equip. Available at once. C-7979.

PORTABLE TOOL ENGR. 14 yr. experience. Until merger chief engr. second largest company. Expert on universal motor design. Inventive ability combined with exec. and business judgment. D-404.

DESIGNING ENGR., E.E. GRAD., 34, married, 8½ yr. experience in design and selling of high tension outdoor substation, indoor and outdoor switching equip., bus supports and connector fittings. Desires employment with utility or mfg. concern, selling or engg., best references. D-389.

E.E. GRAD., 12 yr. comprehensive experience in designing, drafting and engg. of steam and hydroelectric plants, substations and industrial plants. Conduit plans, wiring diagrams. Available at once. D-411.

M.E. AND E.E. FORMER CORNELL INSTRUCTOR IN MACHINE DESIGN for 4 yr. Allis-Chalmers designer and checker, 5 yr. shop apprenticeship and miscellaneous experience, 32, single. Desires teaching or engg. opportunity. Salary open. D-122.

E.E., 14 yr. in field designing, drafting, testing, patent drafting and layout of elec. lt. and pwr. for bldgs. Available now. C-1095.

E.E. GRAD., 39, single. 11 yr. experience in developing, design and mfg. of small apparatus in the elec. measuring instrument line. Bridges for high and low voltage, pwr. to carrier frequencies. Exceptional theoretical training. Desires connection with high grade firm, eventually as sales engr. where exceptional tech. knowledge required. B-8131.

### Draftsmen

DRAFTSMAN AND INSTRUMENT MAN, 25, single, 2 yr. univ. training, 4 yr. experience on pwr. transmission lines, telephone work, and water resources. Available now. Will go anywhere. C-7118.

ME. E.E. AND C.E. GRAD., Italy, 30. single. Has first American citizenship papers. Desires position anywhere with utility or contractor. 3 yr. varied civil engg., 2 yr. in pwr. production, in steam and hydroelectric plants. Skilled in any layout and topographic work. D-422.

**Executives**

EXEC. MATERIAL. Young man, solid foundation in apprenticeship training, followed by engg. and business training, substantial industrial experience, record of accomplishment, integrity, reliability; creative executive ability, desires opportunity to develop as executive material in progressive mfg. organization. C-8775.

E.E. GRAD., 48. 26 yr. experience as designing, pwr., report and exec. engr., with 3 engg. firms, on industrial and utility properties. Experience covers cost of plants, operating economics, system planning, construction supervision and appraisal of properties for various purposes. B-4553.

E.E. GRAD., Univ. of Wis., 33, single. 3 yr. Westinghouse test. 7 yr. supervising pwr. plant, substation, transmission line construction. 8 yr. engg. inspector purchasing, expediting, writing specifications, resident engr., supervising construction. Excellent reference. Can handle responsibility. Desires connection with holding company, utility or mfr. Available immediately. Location, immaterial. B-9661.

E.E. GRAD., 32, single, additional work M.E., Phi Kappa Phi. 8 yr. broad experience, pwr. house, substation, transmission line, duct system design; estimates, standards, equip. specif., operation. Responsible, capable engr. asst. Desires position with mfr. or in plant mgmt. for util. Salary secondary to opportunity. D-124.

E.E., 44, married. 20 yr. with leading cons. engr., utilities, and mfg. concerns. Experience includes responsibility for design, construction, maintenance and operation of power plants and industrial installations. Competent to supervise elec. design, construction, or maintenance. Perfect health, capable, energetic and adaptable. Available immediately. B-9194.

ANALYST of unusual ability, 44, internationally known, 22 yr. experience applying mathematical and engg. knowledge to analysis of existing records of sales, production, qualities of product, etc., to demonstrate additional sales opportunities. Improvements of mfg. and sales policies and more profits followed analyses. Available short notice. Location, immaterial. D-340.

E.E. seeks position in operating dept. of utility or as industrial plant engr. Married. Tech. grad. Factory test floor experience. 17 yr. varied experience with utility and industrial plants. Speaks Spanish fluently. Location, immaterial. Further information on request. Available on short notice. A-4018.

EXEC. ASST. OR EDITOR, Cornell E.E. Grad. 10 yr. asst. to vice-pres. and gen. mgr. Experienced in engg. writing with leading publications, preparation of bulletins and instruction books. Desires exec. work, writing or sales. A-1558.

E.E. GRAD., 32, single. 9 yr. of design and construction of pwr. trans. lines, substations and distribution networks as engg. inspector, purchasing, expeditor, preparing estimates and writing specifications. Excellent references. Desires connection with holding company, operating company, contractor or mfr. Available immediately. Location, immaterial. C-3564.

ELECTRICIAN OR FOREMAN, 25, single, white. 10 yr. experience in coal and metal mining transportation systems. I.C.S. grad., LaSalle Extension Univ. course in indus. mgmt., now taking E.E. course with American School. Speaks English, Slovanian, Spanish. Worked 3 yr. in S. Amer. Will travel. D-380.

E.E. GRAD., Worcester P.I., 1921, 33, married. 8 yr. experience, engg., design, purchase of equip. and construction of pwr. stations, switching stations and substations, 2 yr. in ry. work. Desires sales engg. work. Location, New York, New Jersey metropolitan preferred. Available immediately. C-9928.

EXECUTIVE, 33, E.E. and M.E. Grad. 12 yr. mfg., production, design, advertising, merchandising, accounting desires position involving major responsibilities. Exceptionally wide contact with all types plants throughout country. Characterized as an able organizer and an alert, untiring worker with vision, a highly practical profit-consciousness and quiet aggressiveness. C-1297.

GRAD. ENGR., 34, married. 12 yr. communication, distribution system construction, materials and construction methods supervising engr., cable installation, etc., for metropolitan and mgmt. utilities. Desires responsible position where practical ability, resourcefulness and good personality is required. D-44.

TRACTION ENGR., 28, single, 5 yr. experience in electric traction shops as inspector, since then and at present in charge of service of southeast on registers. 2 yr. at Georgia Tech., later E.E. grad. from I.C.S. Was radio operator. Desires position as asst. engr. for elec. traction. D-80.

E.E. GRAD. Pwr. station design and elec. distribution experience. Desires position in similar field or in research lab. Temporary position will be considered. Preferred location, metropolitan district of N. Y. or Phila. B-1923.

EXECUTIVE, E.E. GRAD., married, 30 yr. experience, mgr., supt., E.E., construction and operation, utilities. Installed steam—Diesel-hydroelectric plants. Building substations, transmission lines, distributing systems, street car network, laying underground and undersea cables. District mgr., sales representative for mfr. of H.T. oil circuit breakers, switches, transformers. Available now. B-2388.

DIVISION SUPT., 29, married, tech. grad. 5 yr. service utility following positions; division supt., district engr., local mgr., construction foreman. 1 yr. supt., construction, operation municipal pwr., ice plant including distribution. 16 months elec. installation, maintenance, industrial mfg. establishment. 2 yr. lineman, construction, maintenance utility. Available. Location, immaterial. D-442.

E.E., M.E. GRAD., married. 22 yr. experience, designing, construction pwr. plants, substations, transmission, distribution systems, industrial plants. 3 yr. charge purchasing engg. equipment, foreign interests. 3 yr. executive experience charge engg. dept. large utility syndicate. English, German, Russian, Armenian languages. Available immediately. D-84.

**Financial**

FINANCIAL ENGR., E.E.M.E. GRAD., Cornell, experience with regulatory commission, utility holding mgmt. corp., security investing dept. of leading insurance company and financial and fact finding investigation. 4 yr. with outstanding consulting engg. firm. Seeks opportunity in New York City. Salary open. C-2953.

**Instruction**

E.E. GRAD., 26, married, 3 months grad. student Westinghouse E. & M. Co. testing large apparatus, switchboards. 3 yr. teaching drafting large mid-western univ. Will receive M.S. deg. in E.E., business administration in spring. Interested power tubes. Wishes to teach E.E., mathematics, physics, drawing, or industrial position. Available June. D-445.

**Maintenance and Operation**

E.E. GRAD., married, 28, with wide experience in industrial plant elec. construction and maintenance; ry. electrification; pwr. plant design, estimating, and supervisory construction experience with elec. contractor; cost analysis. Desires position with future. C-4428.

E.E. GRAD., 1928, 6 yr. hydro and steam plant elec. operation and maintenance, 5 yr. office and cost accounting. Would desire position with utility or mfg. concern in any part of U.S., or foreign. Salary secondary to opportunity. C-7796.

**Research**

ELECTROACOUSTICS, PHYSICIST, 45, married. 20 yr. experience, industrial laboratories, problems of sound, radio, telephone, dielectric phenomena, etc. Several years' experience consulting engr. these fields. M.I.T., physics, Ph.D. Physics, mathematics, Univ. of Chicago. Open for full or part time consultant, director research, special problems in sound and electroacoustics. D-374.

E.E. GRAD., 1930, 25, single, 1½ yr. experience in statistical and industrial research dept. of prominent civic organization in East. Speaks Spanish fluently. Available now due to organization curtailment. C-7551.

PRODUCT ENGR. Grad. engr. with successful record on improvement of product, machines and methods. Experienced in rolling mill methods, non-ferrous fabricating, steel, rubber, and shipbuilding. Industrial applications of elec. and mech. apparatus. Research and experimental work. Location, immaterial. Salary open. B-6342.

**Sales**

SALES ENGR., Cornell two deg., 6 yr. experience selling wire and cable, specializing with ry. in East. Has service on Pennsylvania, New York Central, Erie and Lackawanna, and wide acquaintance among ry. engrs. B-7881.

SALES ENGR., tech. grad., 38, single. Westinghouse test and shop training. 12 yr. sales experience selling steam and elec. apparatus to central station, transportation and marine industries. Desires position as salesman or application engr. B-4274.

INDUSTRIAL ENGR., 30, married, Wisconsin grad. 2 yr. construction, 2 yr. at Westinghouse, 1 yr. utility valuation, 4 yr. industrial sales development. Broad tech. and commercial knowledge various industries. Desires employment in industrial surveys and reports, industrial sales development, investigations for commercial firm. Location, Middle or South West. C-3082.

CONTROL ENGR., E.E. GRAD., 30, married, 8 yr. experience design, development of automatic and drum type control (under 600 volts) a-c. and d-c. Desires permanent connection engg. or sales department of control manufacture or equivalent. Wisconsin location preferred, but will consider any location. Available immediately. D-443.

SALES ENGR., E.E. GRAD. who has contacted pwr. company engr., purchasing dept., elec. jobbers and contractors for 10 yr. in northern-southern Calif. desires to act as local representative for mfr. Married, age 39. Available at once. Location, San Francisco or Los Angeles territory. D-458-10-C-10-San Francisco.

**Testing**

HIGH TENSION CABLE TESTER, expert experience, large eastern utility, 28, married, E.E. grad., 3 yr. Westinghouse test, mchy., switchgear. 5 yr. utilities, construction testing, d-c. to a-c. changeover, consumers complaints, other contact work. Desires responsible position, utility contemplating organizing or reorganizing elec. testing bureau. Available one month's notice. D-440.

## ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
San Francisco
N. D. Cook, Manager

205 West Wacker Drive
Chicago
H. Wierschem, Manager

31 West 39th St.
New York
W. V. Brown, Manager

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

**Men Available.**—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

**Opportunities.**—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

**Voluntary Contributions.**—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

**Answers to Announcements.**—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

# Membership

## Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the secretary before March 31, 1932.

Abel,A.E.,Jr.,Univ.of Ill.,Urbana
Altrup,F.W.,Phil.Stor.Bat.Co.,Washington,D.C.
Arentz,W.,1442 E.13th St.,Brooklyn,N.Y.
Armstrong,J.H.,Univ.of Ill.,Champaign
Arndt,W.F.,1808 N.Bronson Ave.,Hollywood, Calif.
Backstrom,C.W.,Worcester Poly.Inst.,Mass.
Barber,M.H.,Southern Sierras Pwr.Co.,Riverside,Calif.
Barnwell,J.R.,U.S.Engr.Office, Florence,Ala.
Belden,C.L.,The Montana Pwr.Co.,Roundup
Bennett,F.A.,Hart Mfg.Co.,Detroit,Mich.
Bennett,J.O.,Western Elec.Co.,Inc.,Kearny,N.J.
Billette,R.,Gurney Foundry Co.,St.Laurent, Que.,Can.
Bisbee,J.M.,United Elec.Lt.& Pwr.Co., N.Y. City
Blind,K.A.,Milwaukee Elec.Rwy.& Lt.Co.,Milwaukee,Wis.
Bock,F.S.,Jr.,Shell Oil Co.,Coolidge,Ariz.
Boden,A.T.,Brooklyn (N.Y.) Edison Co.
Bookout,A.C.,(Member),Southwestern Bell Tel. Co.,Oklahoma City,Okla.
Brarmann,H.C.,121 Park Ave.,Englewood,N.J.
Brice,R.T.,Emory Univ.,Emory University,Ga.
Brooks,R.E.,Univ.of So.Carolina,Columbia
Brouillard,H., J.A.St.Amour,Ltd.,Montreal,Que. Can.
Brown,C.B.,23 West 84th St.,N.Y.City
Brugge,B.J.,Lincoln Elec.Co.,Cleveland,Ohio
Buckley,S.W.,Gen.Engg.Co.,Wilmington,Del.
Buge,A.,1241 South 24th St.,Milwaukee,Wis.
Bullock,N.,Panama City,Fla.
Burtis,J.H.,(Member),Westchester Co.Sanitary Comm.,White Plains,N.Y.
Calkins,E.H.,2218 Horton Ave., S.E.,Grand Rapids,Mich.
Canning,G.R.,Ohio Bell Tel.Co.,Cleveland
Carlston,J.O.,837 So.6th East,Salt Lake City, Utah
Ceserani,F.L.,Montana Pwr.Co.,Helena
Chakrabarty,M.N.,Purdue Univ.,W.Lafayette, Ind.
Chandler,J.A.,Cleveland Bd.of Education,Ohio
Church,C.A.,Univ.of Colorado,Boulder
Clark,E.B., Farrel-Birmingham Co., Ansonia, Conn.
Clemens,N.O.,Quakake,Pa.
Closey,W.M.,Mich.Bell Tel. Co.,Detroit
Conklin,C.E.,Walker,Minn.
Conroy,E.W.,(Member),Puget Sound Pwr.& Lt.Co.,Bremerton,Wash.
Cook,C.D.,N.Y.& Queens Elec.Lt.& Pwr.Co., Flushing,N.Y.
Cope,D.S.,Univ.of Minnesota,Minneapolis
Curtis,R.M.,Penn.Rr.,Rahway,N.J.
Damidovich,J.F.,R.D.No.2,Aurora,Ill.
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March 1932

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8 Foreign

# Engineering Literature

## New Books

### In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during January are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

POWER PLANT MANAGEMENT. W. N. Polakov. N. Y. & Lond., McGraw-Hill Book Co., 1932. 176 p., 8x5 in., cloth, $2.00.——Outlines an efficient and economical method for organizing the human side of power-house work in various factories and power plants, including duties of various employees, methods of accounting and recording, and wages.

THOMAS A. EDISON, Benefactor of Mankind. By F. T. Miller. Chicago, Phila., Toronto, John C. Winston Co., 1931. 320 p., 9x6 in., cloth, $1.50.——A well illustrated popular life of Edison, the first since his death, with the cooperation of the family and associates of Edison. An excellent account.

RECOLLECTIONS OF EDISON. By D. T. Marshall. Boston, Christopher Publishing House, 1931. 117 p., 8x5 in., cloth, $1.75.——Dr. Marshall's contribution to Edisonana, though slight, has some interest. As a boy in Metuchen, he was familiar with the Menlo Park laboratory; in 1887 he became a chemist at the West Orange laboratory. His recollections deal with the appearance of the laboratories at that time, the men who worked in them, and their methods and activities.

SYMPOSIUM ON WELDING. American Society for Testing Materials. Phila., 1931. 151 p., 9x6 in., cloth, $1.75.——Eleven papers presented at a meeting of the society in Pittsburgh, March 1931, with discussions. Includes a general survey of processes, account of processes for welding aluminum, and papers on materials for fusion welding, modern applications of arc welding and recent developments in gas welding. Other papers discuss matters of inspection and testing in the use of the stethoscope, gamma-ray testing, magnetic testing, and fatigue and impact tests.

V D E FACHBERICHTE, 1931. Berlin, V D E—Verlag. 177 p., 12x8 in., paper, 12 RM; bound, 14 RM.——This report contains the technical papers presented at the 1931 convention of the Society of German Electrical Engineers. The theme of the meeting was long distance power transmission, discussing power generation, transmission, interconnection, power utilization, etc. Includes 62 papers.

HANDBOOK OF CHEMISTRY AND PHYSICS. By C.D. Hodgman and N.A. Lange. 16 ed. Cleveland, Ohio, Chemical Rubber Publ. Co., 1931. 1545 p., 7x4 in., cloth, $5.00.——The new edition of this popular handbook contains 180 pages more than the previous one, in addition to extensive revision throughout the book. The book continues to be an exceedingly useful reference work for the student and research worker, presenting a large collection of frequently used data in convenient form.

INTRODUCTION TO THE HISTORY OF SCIENCE. V. 2 in two parts. From Rabbi Ben Ezra to Roger Bacon. By George Sarton. Publ. for the Carnegie Institution of Washington, as Pub. No. 376, by Williams & Wilkins Co., Baltimore, 1931. 1251 p., 11x7 in., cloth, $12.00.——A masterly survey of the growth of scientific thought and achievement over the twelfth and thirteenth centuries. An inventory of mediaeval science, East and West, on a scale never before attempted, indispensable to students

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Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

INDEX TO A.S.T.M. STANDARDS AND TENTATIVE STANDARDS. Phila., American Society for Testing Materials, 1931. 103 p., 9x6 in., paper, free.——Combined index, covering all A.S.T.M. standards in effect in Sept. 1931, telling in which publication they can be found, and making it easy to determine whether a particular specification exists and where it may be found.

APPLIED GYRODYNAMICS. By E. S. Ferry. N. Y., John Wiley & Sons, 1932. 277 p., 9x6 in., cloth, $4.00.——The purpose of this work is to present gyrodynamics to the acquaintance of engineers and students having the mathematical equipment of the ordinary graduate of engineering or physics. It considers such important devices as the gyrohorizon, the gyrosextant, the gyrocompass and gyrostabilizers for ships and monorail cars.

NEW CONCEPTIONS OF MATTER. By C. G. Darwin. N. Y., Macmillan Co., 1931. 224 p., 9x6 in., cloth, $3.00.——This book, based on Prof. Darwin's Lowell Institute lectures in 1931, is a clear description of the broad features of the new mechanics in non-technical language without the use of mathematics. The book is not light reading but calls for no technical knowledge upon the part of the reader.

THEORETICAL PHYSICS. V. 1. Mechanics and Heat. Newton-Carnot. By W. Wilson. N. Y., E. P. Dutton & Co., 1931. 332 p., 9x5 in., cloth, $6.00.——Prof. Wilson's aim is to present an account of the theoretical side of physics which will be sufficiently comprehensive to be useful to students, without being too elaborate and voluminous. This volume, the first of three, deals with mechanics and heat. The subjects are developed according to their historical growth.

EINFUHRUNG IN DIE THEORIE DER SCHWACHSTROMTECHNIK. By J. Wallot. Berlin, J. Springer, 1932. 331 p., 10x7 in., paper, 21.50 RM; bound, 23 RM.——An introduction to the theory of telegraphy and telephony based upon courses given in the central laboratory of Siemens & Halske to the laboratory staff. A book on concepts and developments of weak-current theory in an easily understandable form.

DIE ELEKTRISCHEN MASCHINEN; Bd. 1. Allgemeine Grundlagen, by M. Liwschitz. 2nd edit., 381 p., 18 RM. Bd. 2. Die elektrischen Maschinen, by M. Liwschitz and H. Glöckner. 1st edit., 306 p., 19 RM. Leipzig & Berlin, B. G. Teubner, 1931. 9x6 in., cloth.——To give the young engineer an understanding of the relationship between natural laws and electrical machine behavior so as to equip him for advanced study and independent work as a designer.

# Industrial Notes

**Allis-Chalmers Appoints L. W. Grothaus.**—Announcement has been made that L. W. Grothaus succeeds C. E. Searle as general representative of the Allis-Chalmers Manufacturing Company, Milwaukee. Mr. Searle resigned on January 31 to become vice-president of an eastern firm. Mr. Grothaus has been affiliated with the Allis-Chalmers Company since 1904. Prior to his promotion he was assistant manager of the electrical department.

**American Transformer Appointments.**—Announcement has been made by the American Transformer Company, Newark, N. J., of the appointment of two sales representatives. Edgar M. Moore Company, Farmers Bank Building, Pittsburgh, will handle sales of AmerTran industrial transformers in western Pennsylvania, southern Ohio, and West Virginia. Theodore F. Mueller, 3-260 General Motors Building, Detroit, will handle sales of all AmerTran products in the entire state of Michigan with the exception of the upper peninsula.

**Steel Tubes Announces Appointment.**—Morgan P. Ellis has been appointed vice-president in charge of all sales. Murray J. Whitfield is general sales manager of the electrical division in charge of sales of "Steeltubes" electrical metallic tubing (thin wall conduit).

**General Electric Orders in 1931.**—Orders received by the General Electric Company during the year 1931 amounted to $252,021,496, compared with $341,820,312 for 1930, a decrease of 26 per cent, President Gerard Swope has announced. Orders for the quarter ended December 31 amounted to $49,321,480, compared with $74,168,480 for the last quarter of 1930, a decrease of 34 per cent.

**Insulator for Universal Clips.**—Rubber insulators of a new and improved style are now being offered for Universal clips. These new insulators have an extended tubular portion at the rear which insures that any bending of the cord near that point takes place on a relatively large arc, thus preventing breakage of the copper conductor. A further feature of the new insulator is an interior constricted ring of rubber, which serves to keep the insulator from slipping down on the cord when the clip is applied to a terminal. An interior arrangement of the insulator makes it possible to mount it on the clip either with the nose exposed or with the clip completely enclosed, so that the nose is flush with the outer opening. This latter position is often desired, as it prevents the clips short-circuiting with each other when knocking about on the test floor, test bench or laboratory table. Mueller Electric Co., 1583 East 31st St., Cleveland.

**Electrolytic Condensers for Capacitor Motors.**—With considerably improved characteristics due to a radical departure in the formation of the oxide dielectric film on the aluminum foil, the small electrolytic condenser is ready to go outside the radio field and find many applications in electrical and industrial functions according to William Dubilier, pioneer condenser designer and manufacturer. "Recently, our engineers have developed a new and radical means of forming the oxide film on the electrolytic condenser foil," states Mr. Dubilier. "Not only do we obtain a tougher dielectric film, capable of higher working voltage and faster comeback in the event of a breakdown, together with a more favorable power factor, but the very nature of our new forming process conserves the electrolyte for a longer service life. We now find it possible to employ electrolytic condensers for capacitor motor functions. The 110-volt or 220-volt a-c. electrolytic units are proving satisfactory for starting and intermittent service. The fact that a very high capacity is obtainable at a very low cost, makes these capacitors highly desirable today."

**A New Oil Purifier.**—A new type of centrifugal oil purifier for transformer and circuit breaker oil, in which the oil is centrifugally purified under a high vacuum, has been introduced by the Sharples Specialty Company, of Philadelphia, under the registered trade name of "Deoxator." It is claimed that this machine not only removes any free air in the oil, but also removes 90% of the oxygen in solution and any dissolved moisture. The removal of the oxygen in solution tends to reduce the formation of sludge through oxidation while the removal of dissolved moisture produces a dielectric that will last longer.

The Deoxator can be used effectively for the following work: for filling and "drying out" new equipment; for filling Inertaire type transformers to eliminate second blowing with nitrogen; for centrifuging oil in transformers that are designed to prevent air contact and preventing the introduction of any air whatsoever into the transformer; purifying oil for oil filled cables; purifying oil in subway type transformers that are sealed up tight; for producing a purified oil with less sludge forming tendencies and having a more persistent dielectric. In the Deoxator the centrifuge bowl is still used to remove free water and sludge while the vacuum removes dissolved moisture and oxygen in solution. Unless the free water is removed first by the centrifuge bowl, the vacuum efficiency is destroyed by the surplus water vapor.

# Trade Literature

**Motors.**—Bulletin 173, Part 4, 2 pp. Describes brush-riding repulsion-induction motors. Wagner Electric Corp., 6400 Plymouth Avenue, St. Louis.

**Indoor Bus Supports.**—Bulletin GEA-924B, 32 pp. Describes in detail various types of bus supports available to meet the requirements of various installations. General Electric Co., Schenectady, N. Y.

**Aluminum Bus Bars.**—Booklet, 20 pp., "Channeluminum Electrical Conductors of Alcoa Aluminum." Includes illustrations and diagrams as well as installation photographs. Aluminum Company of America, Pittsburgh, Penna.

**Constant Voltage Regulators.**—Bulletin 5501. Describes Ward Leonard constant wattage voltage regulators for eliminating the distortion and inaccuracies of photo-cell devices resulting from voltage fluctuation. The device is a voltage transformer and regulator combined, reducing the a-c. line voltage to that required by the exciter lamp, and maintaining the exciter lamp voltage constant regardless of instantaneous fluctuations in line voltage. The design of the regulator is such as to compensate for variations in lamps of the same nominal rating and to correct for the increase in lamp resistance due to aging. The regulators are used to maintain constant voltage with various types of loads, constant or variable, with leading or lagging power factors. Ward Leonard Electric Company, Mount Vernon, N. Y.

**Thrustors.**—Bulletin GEA-1262B, 24 pp. Describes G-E Thrustors for producing a straight-line, constant-pressure thrust from an electric motor drive. There are two general fields of application of these units: (1) to supply pressure and actuate lever mechanisms, (2) to replace muscular effort with electric control on foot- or hand-operated machines. The device can be installed easily on practically any type of equipment. It handles clutches and brakes in such a way as to prevent strain and excessive wear; it can be utilized to increase production; to afford greater safety for the workman, and to give complete electric control. Typical installations are illustrated on punch presses, spot welders, hoists and elevators, valves, conveyors, and for opening and closing sliding, swinging and lift doors. General Electric Company, Schenectady, N. Y.

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## This Month—

### Front Cover

Reputedly the only one of its kind in the United States, the marble dome of the Rhode Island Capitol is floodlighted by seven groups totaling 109 projectors, 67 kw. in lamps. Providence is host city to the May meeting of the North Eastern District, and the prominently lighted dome of the Capitol may serve well as a landmark for those motoring in at night.

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Officers and Committees (For complete listing see p. 71-76, January 1932 issue of ELECTRICAL ENGINEERING.)

ELECTROCHEMISTRY represents a fruitful field for the application and utilization of electric power; furthermore it holds many opportunities for the young electrical engineer with some knowledge of chemistry. *p. 238–242*

EDUCATION "after college" has met with surprisingly successful results according to a report issued recently by the chairman of the educational committee of the Institute's Chicago Section. *p. 280–281*

PROPER control of lines interconnecting two electric power systems is a problem in load control rather than frequency. Special equipment has been designed to accomplish this and has been found to operate satisfactorily with frequency control equipment on one of the systems. *p. 256–260*

COMMITTEES already have been appointed and are busy preparing for the coming A.I.E.E. summer convention to be held in Cleveland, Ohio, in June. *p. 275*

THE de Laszlo portrait, for which President Hoover recently sat, was unveiled in the Engineering Societies Building, New York, on February 15. *p. 273*

IF REGISTRATION records are an accurate indication, the district meeting held recently in Milwaukee may be classed as an unqualified success. *p. 270–271*

EXPERIMENTS show that of the total current passing through the body during electric shock, only a small percentage actually passes through the heart. *p. 242–244*

PAPERS presented at the recent A.I.E.E. winter convention were liberally discussed by those attending; as much of this discussion as space permits is presented in summarized form in this issue. *p. 272–279*

MORE than 1,200,000 synchronous electric clocks are said to have been sold in 1930. Tests over a period of several weeks show the maximum deviation of these instruments to be only 44 sec. *p. 228–232*

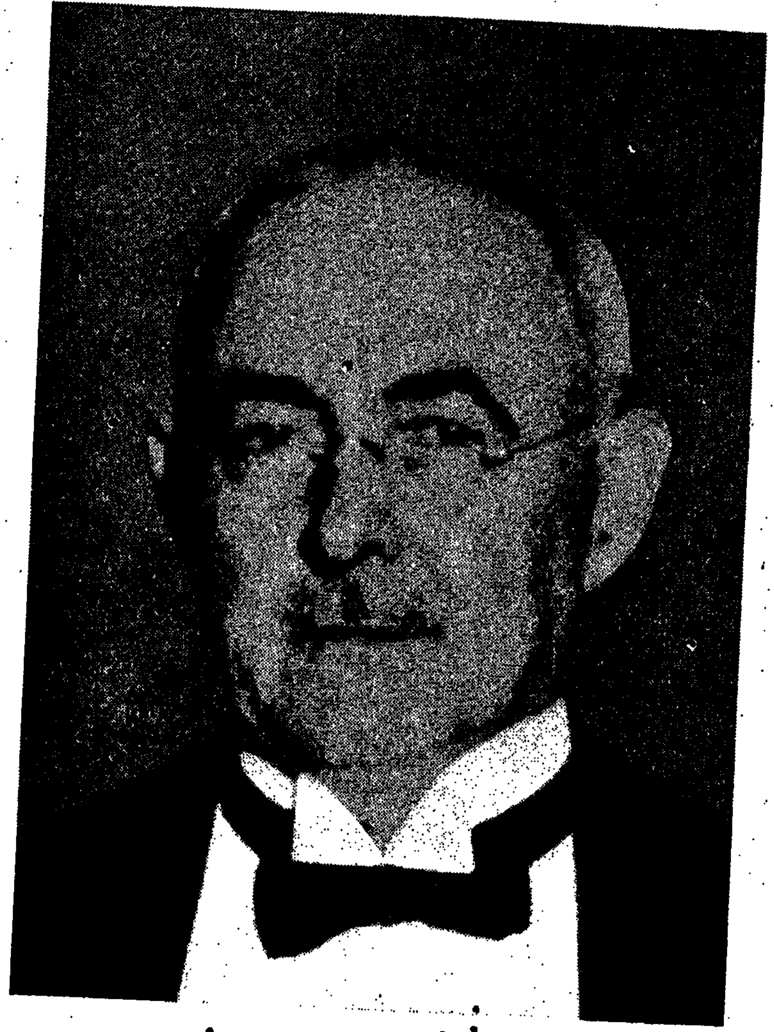
STABILITY studies of metropolitan electric power systems often pave the way for more reliable or economical system layouts. Curves have been developed by which the transient stability may be determined for any system of this type. *p. 232–237*

A RECENT survey shows that 6 per cent of the total railway mileage of the countries of Western Europe are electrified. This percentage is increasing yearly, and despite the present economic crisis 1,042 more route miles now are under construction or authorized. *p. 244–252*

PLANS are practically complete for the Providence meeting of the A.I.E.E. North Eastern District. A well-rounded program with many attractive features has been arranged. (*p. 268–270.*) Interpretive abstracts of all technical papers to be presented appear in this issue. *p. 263–267*

# FREDERICK LANE HUTCHINSON

## 1866—1932



Born at Elizabeth, N. J., April 2, 1866, to Elizabeth (Pring) and John Hutchinson; graduated from Cornell University, 1893; with the Westinghouse Electric & Manufacturing Company from 1893 to 1901; became an Associate of the Institute in 1894; manager of publications for the C. W. Hunt Company of New York, 1901–2; advertising manager for the National Electric Company of Milwaukee, 1902–3; sales manager for the same company, 1903–4; took up special work on the Institute TRANSACTIONS in 1904; appointed Assistant National Secretary in 1908; became National Secretary in 1912; transferred to grade of Member of the Institute, 1913; married Grace Lawrence Duryee of San Diego, Calif., June 27, 1921; represented the Institute at the World Power Conference, London 1924, and at the World Engineering Congress, Tokyo, 1929; died Friday, February 26, 1932.

A MEMORIAL RESOLUTION, adopted by the Executive Committee of the American Institute of Electrical Engineers,—

**WHEREAS: The death of Frederick L. Hutchinson has removed from the American Institute of Electrical Engineers one of its most devoted members and a leader of marked ability and high ideals,**

**WHEREAS: During his service of twenty-eight years as a member of the staff, including twenty years as national secretary, he worked unceasingly and effectively for the best interests of the membership and the advancement of the entire engineering profession, exhibiting at all times remarkable enthusiasm, unselfishness, and wisdom,**

**WHEREAS: His delightful personality, his deep interest in the wide range of activities of the Institute and organizations with which it cooperated, his keen grasp of all questions involved, and his unfailing tact on all occasions, won the respect and admiration of a multitude of friends, be it therefore**

**RESOLVED: That on behalf of the membership, the executive committee hereby expresses its profound sorrow at the death of one of the Institute's outstanding leaders, and extends to the members of the family of Mr. Hutchinson its deepest sympathy, and be it further**

**RESOLVED: That these resolutions be inscribed in the minutes of the Executive Committee and a copy be transmitted to the members of Mr. Hutchinson's family.**

# Synchronous Electric Time Service

**Commercial a-c. time service has been made possible by the development of a self-starting synchronous motor and of a master clock to indicate deviations of power system frequency from normal. Construction, accuracy, and application of various types of these devices are described in this article.**

By
H. E. WARREN
ASSOCIATE A.I.E.E.

Warren Telechron Co.
Ashland, Mass.

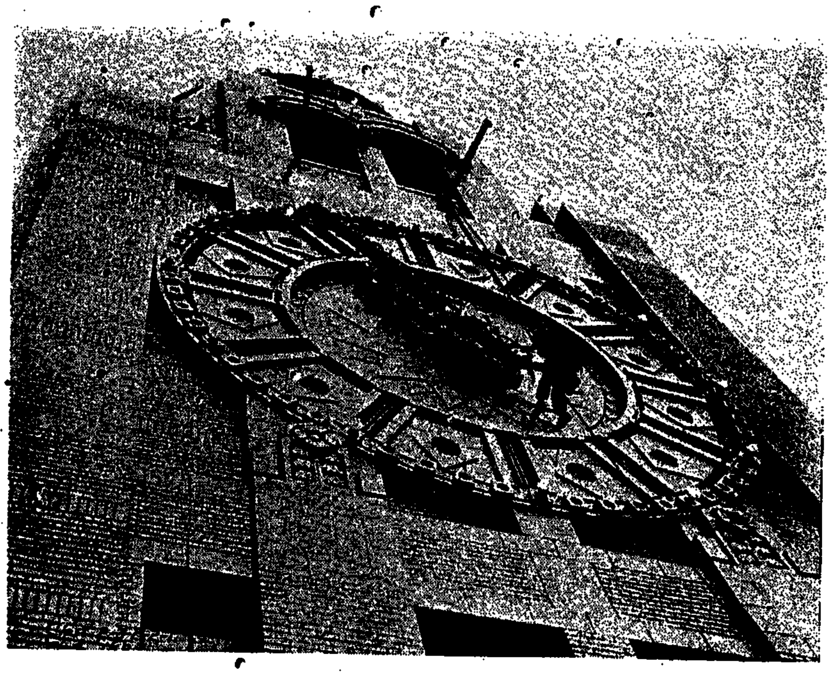


Fig. 1. Dial of a large synchronous tower clock. Illuminated at night, the characters around the circumference flash in succession to indicate seconds

BEFORE the beginning of the present century there were a few individuals who realized the possibility that commercial alternating current, by means of its recurring pulsations, might be used in some manner to measure time; but dreams of this nature did not materialize in practical performance.

Up to 1916 there was no commercial a-c. system in existence in which generator speed was regulated with sufficient accuracy so that the current could be used for the purpose of indicating time by means of synchronous clocks. At that time two devices were brought out which in the succeeding years made possible commercial a-c. time service.

The first of these devices was a self-starting synchronous motor utilizing residual magnetism to permit a rotor to start and run at synchronous speed. This type of motor differs from all the common forms of a-c. motors in that eddy currents induced either in the mass of the rotor or in some form of winding upon the rotor are not utilized to start the rotor from rest. Instead, the rotor is made of such permanent magnetic material and is so proportioned with respect to the field that remanent magnetic poles are set up in the rotor material by the a-c. magnetism of the field in such a manner as to cause the desired motion. Such a motor is sometimes known as a hysteresis motor. Fig. 2 shows a view of a recent model.

The hands of a clock were connected by a gear train with the first of these self-starting synchronous motors and this clock, supplied by current from the local electric light system, was compared with standard time at intervals over a period of several weeks. The new motor driven clock proved to be a very inferior timekeeper, developing daily errors as great as 5 or 0 min., thus proving the need of greater accuracy in ie average frequency of the power supply if it were be used for timekeeping.

By observing these daily errors it was easy to compute the average value of the system frequency. There are 1,440 min. in a day and the gearing of the clock was such that if the frequency had been exactly 60 cycles, there would have been no time error; a 1 per cent error in average frequency (0.6 cycles at 60 cycles) would mean 1 per cent error in the time of the clock, which amounts to 14.4 min. per day. The actual, computed error in the average frequency as determined by these observations is shown in the upper curve of Fig. 3 which was originally published in the article, "Clocks in the Field of Electric Light Appliances" in the N.E.L.A. *Proc.*, 1917, Commercial Sec., p. 641.

The second device consisted of an indicating instrument that would show to a generating station operator directly in terms of time, deviations of average frequency from standard. Guided by this instrument, an operator could so regulate the speed of his generators as to maintain such small deviations from standard average frequency that the alterations could be used to measure time for all ordinary commercial purposes. Fig. 4 shows the dials of a type of master clock which is in common use. The large dial in the center has two hands, one black and the other gold. The black hand makes a revolution on the dial every 5 min., its rate of motion being regulated by an accurately adjusted pendulum beating seconds. The gold hand is driven by a gear train directly from one of the Telechron self-starting motors. The gear ratio is such that when the average frequency is correct, this hand will also make one revolution in exactly 5 min.

The two hands are started off together, and so long as the average frequency remains correct, will keep together with no visible angle between them. An error in the average frequency will cause the gold hand to move slightly faster or slower than the black hand and they will become separated. The angle of separation will be a direct visible measure of the error in the integrated alternations, which may be conveniently called the system time. If the gold hand is ahead, this will show that the system time is fast; if behind, that it is slow.

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Based upon "Synchronous Electric Time Service" (No. 32-40) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932.

An error in the average frequency as small as 1/60 cycle will cause a spread of 1 sec. between the two hands of the master clock in 1 hr. If such an error continues, the spread will continue to increase as time passes. The accuracy of the indication is limited only by the timekeeping precision of the pendulum itself. When carefully regulated this is better than 1 sec. per day, or an absolute precision of about one part in 100,000.

When the operator at the generating station which is regulating frequency adjusts the turbine governors from time to time so as to keep the black and gold hands of the master clock together, he automatically causes all other synchronous motor clocks on the same system to keep correct time. The lower curve of Fig. 3 shows the great improvement in the average frequency value obtained after the first master clock installation.

The standardization of average frequency is of great value to the power companies in the following ways:

1. By improving the service furnished manufacturing establishments, insuring more uniform speed of motor driven machinery and generally assuring the quality of the product.
2. By facilitating interconnection with other power companies which have correspondingly standardized their frequency.
3. By enabling power companies to use synchronous motor movements in their maximum demand meters and graphic recorders, thereby obtaining more accurate and synchronized records at lower cost of maintenance.

Before master clocks were available, the inherent errors in frequency indicators were sufficient to handicap operators on interconnected systems in their efforts to equalize the frequency preparatory to synchronizing the two systems, and to lead to controversy as to the true value of the frequency after the two systems were synchronized.

Master clocks have been adopted generally by the power companies of the United States for the purpose of regulating frequency. At the present time it is estimated that the regulation of the current to over 90 per cent of the consumers' meters in this country is guided by these master clocks.

The accuracy which may be expected at present from a synchronous electric clock is indicated by the records shown on Fig. 5. The records shown on this chart are taken from four typical very large interconnected systems east of the Mississippi River. The ordinates of the curve in each case are seconds deviation from standard time, and the abscissas, weeks over a period of 5 months. The solid line through the center of each curve represents standard time, and the two points plotted for each day at the top and bottom of the band represent the maximum range of the deviations from standard for that day. The widest deviations shown are 44 sec. fast or slow, which means that on these systems a synchronous clock set absolutely accurately with standard time, did not indicate incorrect time more than 44 sec. fast or slow through the period plotted. The records of the two systems which show the smallest departure of standard time indicate that a clock operating on these systems would never be more than 9 sec. fast or slow. There are few uses of time which justify higher accuracy, and even the worst of these records is far superior to that of previous types of commercial clocks.

Some power companies throughout the country may be giving better than the best time service indicated on this chart; probably there are some permitting wider variations. Practically all power companies, however, are giving sufficiently accurate frequency regulation to provide far better time on synchronous clocks than previously available on commercial clocks.

All factors in power system development are tending to require continued improvements in frequency regulation. As a matter of fact the very large interconnected systems have so much momentum stored

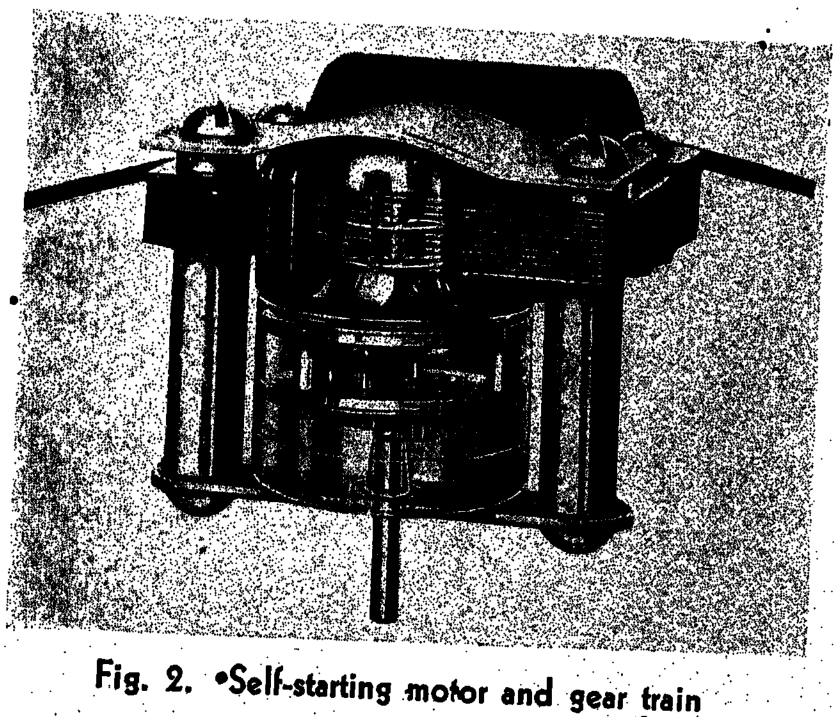

Fig. 2. Self-starting motor and gear train

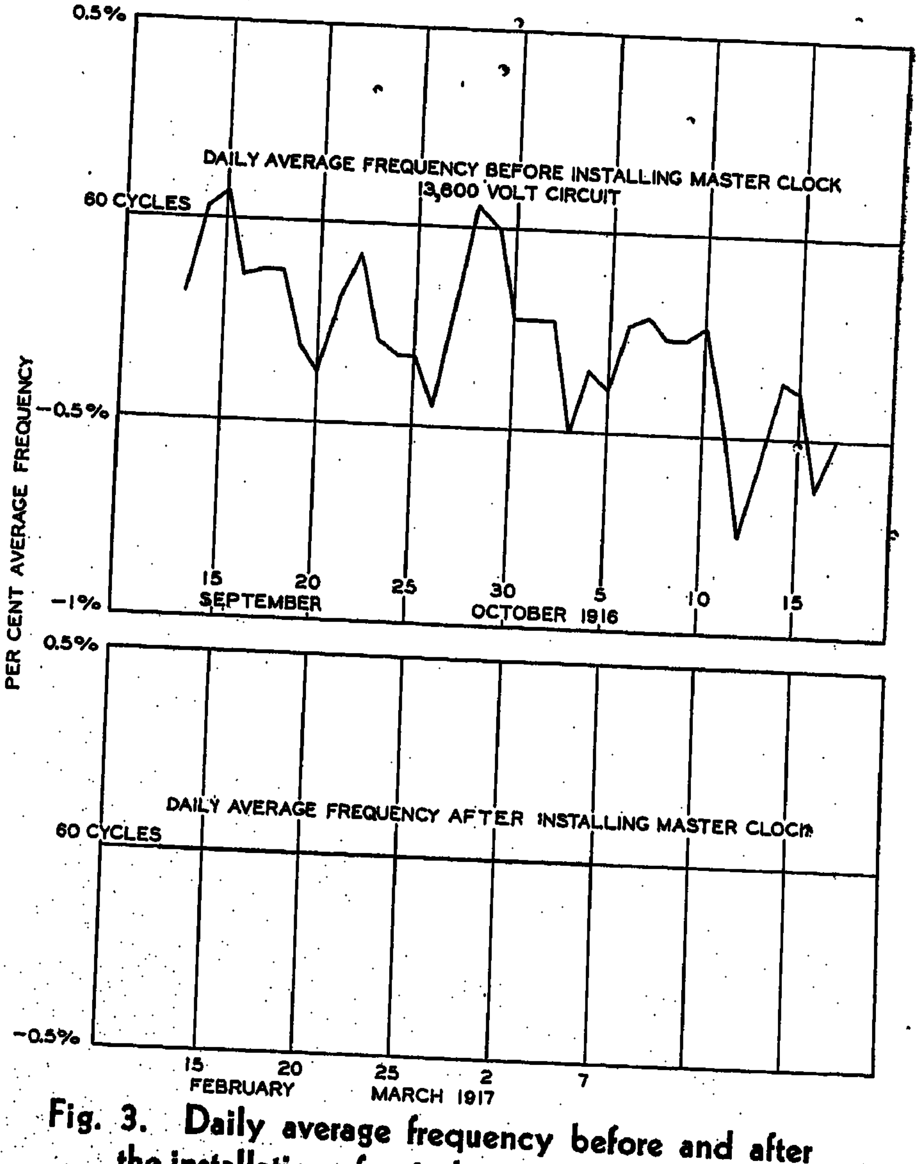

Fig. 3. Daily average frequency before and after the installation of an indicating master clock

in rotating equipment (generators, motors, etc.) that when properly adjusted at the beginning of a flat load period, they will give almost perfect time with no adjustment of governors for speed. Over the irregular portions of the load curve, however, governor adjustment is necessary and much work is being done at present to divide the burden of this regulation on large interconnected systems between the various power companies by the use of automatic frequency control to supplement the master clocks. When perfected and applied, these instruments will undoubtedly reduce the system time error to insignificant values of the order of 1 or 2 sec.

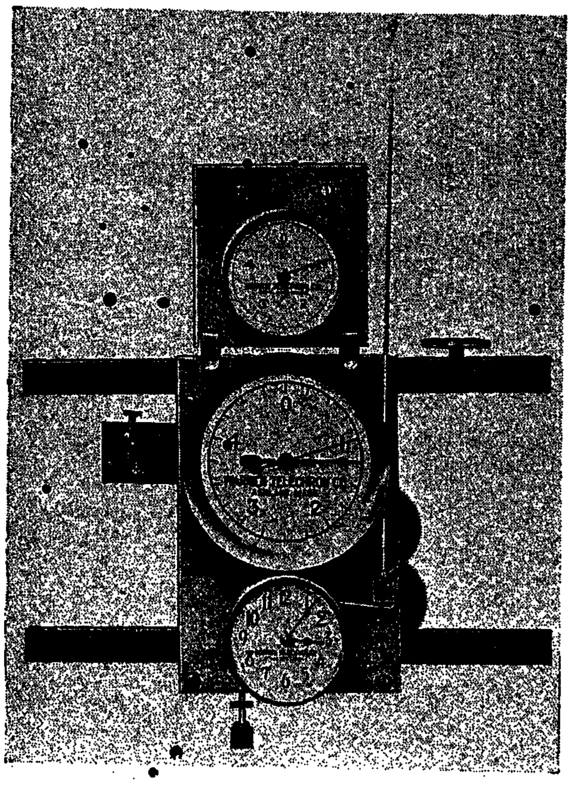

**Fig. 4. Operating dials of a common type of master clock**

## Synchronous Clock Motors

About 1928, twelve years after alternating current regulated by means of master clocks as illustrated in Fig. 4 became available, there appeared on the market the first of several new varieties of synchronous motors suitable for use in clocks. These motors may be divided into two classes; non-self-starting and self-starting.

The non-self-starting motors, of which there are several kinds, generally have toothed, soft-steel rotors. The usual stator construction is bipolar with teeth on each pole corresponding to the spacing of the rotor poles. In all multi-polar motors of the common varieties the speed is found by dividing the number of current alternations per minute by the number of rotor or stator poles. In nearly all cases no attempt is made to introduce a rotating component into the field. A common arrangement of rotor and stator is shown in Fig. 6. On account of the difference in magnetic reluctance between rotor positions, where the poles do or do not correspond with the stator poles, a strong reactance torque exists when the rotor is at rest. This tends to prevent the rotor from starting; but when running at synchronous speed, tends to keep it at that speed.

It is somewhat difficult to spin such a rotor by hand so as to cause it to lock into synchronism with the alternating field unless some means is provided which will permit a sudden phase shift of the rotor poles as the rotor speed passes through its synchronous value. Among the satisfactory schemes for accomplishing this result is the use of loosely coupled fly-wheels on the rotor shaft or spirally arranged rotor poles with means for the axial shifting of the rotor in the field. Also, when started by hand, mechanical launching devices sometimes are used to bring the rotor up to approximately synchronous speed automatically.

The self-starting synchronous clock motors which have appeared within the last few years utilize a-c. fields with rotating components brought about by the use of shading coils. Most of these motors have multi-polar rotors with some form of squirrel-cage winding or a copper element wherein Foucault currents are induced by the rotating field. Like ordinary induction motors, such motors get their starting torque through the reaction of the Foucault currents in the field. Synchronous driving torque in these varieties of self-starting motors is produced by polar projections of the steel rotors or by a separate polar element loosely coupled to the rotor shaft. One variety of the recent self-starting synchronous motors utilizes remanent magnetism for starting and for synchronous operation.

Any of the rotors described heretofore may be used to drive the hands of a clock through a simple train of gears. Two forms of such gear trains are in common use, one composed entirely of spur gears and the other utilizing worm gears and worms. On account of the greater efficiency of transmission, a spur gear train is better for large clocks, but for small clocks the other mechanism is satisfactory. Frequently the high-speed gears of a spur-gear train are made of nonmetallic material so as to run more quietly, and the motor or the whole clock movement is usually mounted on cushioning material so as to reduce the a-c. hum. Some clocks are much quieter than others, depending upon the rigidity of the field laminations and the design of the moving parts.

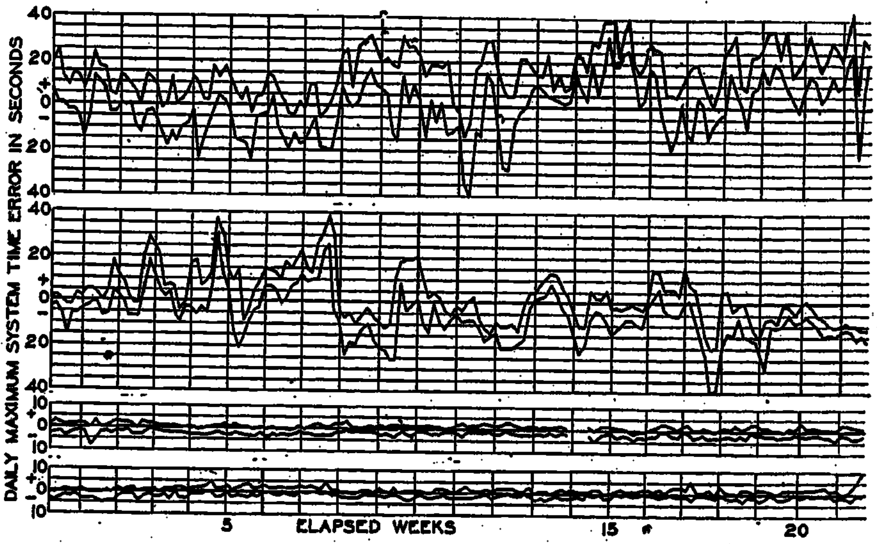

**Fig. 5. Maximum daily system time errors of four large power systems**

Any one of the motors mentioned is adequate to drive the hands of a clock dial 12 in. or less in diameter. The actual output required for this purpose is exceedingly small. If the clock hands are balanced and the gear train is fairly efficient, not more than one twenty-millionth of a horsepower is needed for a 12-in. dial. The power output of the various motors ranges from less than one-millionth of a horsepower to more than one-ten thousandth of a horsepower. The larger amount has been found adequate to drive tower clocks 10 or 12 ft. in diameter. The power output of these motors seems exceedingly small as compared with commercial motors used for other purposes; nevertheless it is, fully adequate for this timekeeping duty, and is many times greater than the power of ordinary spring clock motors.

The electric input to these motors is generally in the neighborhood of 2 watts, but as the power factor is low, the voltamperes vary from three to six. Obviously the efficiency of these motors is very low indeed, amounting to a fraction of 1 per cent. However, the power used is so little (17 kw-hr. per year or approximately $1.00 worth) that this feature is of minor importance.

Most synchronous motor clocks are provided with some form of indicator visible through a small hole in the dial. In clocks which are not self-starting this indicator, by its continuous motion shows that the clock is in operation. After an interruption in the current, the motion of the indicator stops permanently. In self-starting motor clocks of the Telechron brand, the indicator back of the dial shows a steady white target as long as the current flows. This target changes to red and remains so after an interruption in the current supply, although the clock of course starts and continues to run as soon as the power is restored.

Inasmuch as most kinds of synchronous motor clocks either will stop permanently or show errors after current interruptions, it is reassuring to know that system interruptions are rare in our thickly settled districts. Often these clocks continue to show correct time within a very few seconds for many months, even for years. In order to provide against the rare stopping of the hands because of interruptions, clocks have been available for many years which have auxiliary spring movements. These movements appeared more necessary in the beginning before a-c. service had become as reliable as it is today.

The successful operation of synchronous motor clocks is quite independent of certain influences which are detrimental to other clocks, such as level position, vibration, and ordinary temperature variations. Extreme temperatures near zero fahr. will stop some kinds of clock motors, but other varieties will operate well below zero.

## APPLICATIONS

Application of these small clock type synchronous motors to many devices and instruments has been going on ever since these motors became available. The first users were the power companies themselves who had many instruments and meters, especially those of the maximum demand type which required timekeeping elements. The spring clocks used for these purposes were inaccurate, troublesome, and costly to maintain. This was especially true because they needed frequent winding and often were located at distant points. The instrument load was sometimes too great for a spring clock to handle with accuracy. As soon as the motors were substituted for the spring clocks there was a great gain in accuracy and reliability and the costly winding was eliminated. It then became possible to redesign the instruments so as to give still better performance.

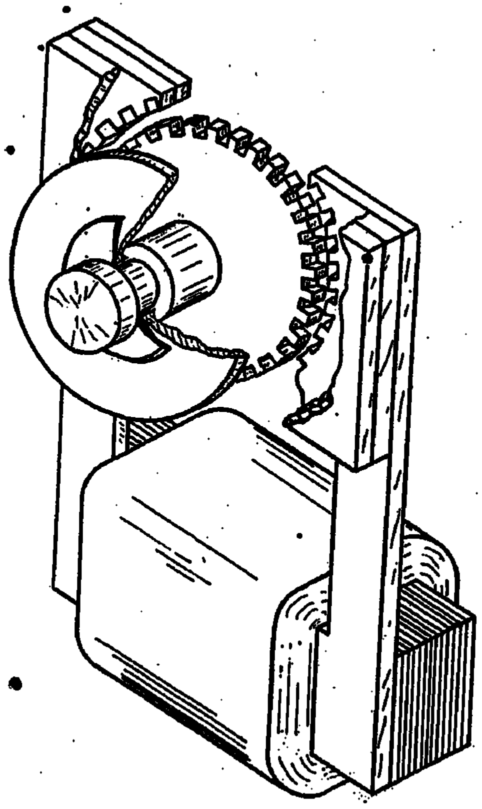

Fig. 6. One type of non-self-starting synchronous clock motor

Gradually nearly all the makers of instruments began using synchronous motors in place of spring movements, until now the list of such motor driven instruments is nearly a complete catalog of devices in which the measurement of time is involved. The largest class of these motor driven instruments is perhaps the graphic recording type. The load of driving a paper chart, especially of the strip type, is very great for a spring clock but comparatively trifling for a synchronous motor. Moreover, the motor can handle a roll of paper so as to make a continuous record for weeks or months without regard to winding. There are also many kinds of instruments which do not make a record but serve to control or actuate, and synchronous motors have been incorporated advantageously into certain forms such as time switches, temperature controllers, traffic signals, etc.

There is a large and important class of timing devices exclusive of ordinary clocks. Among them are numerous kinds of time and cost recorders, program machines, time stamps, etc., wherein synchronous motors have gradually been replacing spring clock movements. In many cases this change has made it possible to eliminate local master clocks, batteries, and expensive wiring.

In building installations, where synchronous clocks, or timing devices driven by synchronous clock motors are numerous it is usual for the customer to provide a so-called "resetting device" or a duplicate source of a-c. energy to guard against the effect of interruptions in the supply of current. In all such installations a separate wiring system is used, connected with the public service system through a suitable switchboard.

The resetting device automatically measures the duration of an interruption and after the current is restored, applies higher frequency or otherwise speeds up the clocks until again they are correct.

The problem of driving very large tower clocks by means of self-starting synchronous motors is much less difficult than that formerly involved in the use of conventional pendulum tower clock movements. Of course it is necessary for the gears and shafts to be very strong because the stresses due to the great weight of the hands and the pressure of the wind are rather high. Fig. 1 shows a tower clock movement installed on the Williamsburgh Savings Bank at Brooklyn, N. Y., where each of the four dials is 26 ft. in diameter and the hands alone weigh 700 lb. per pair. The hour hand sleeves of this clock are of steel and their outside diameter is 4 in. The power required to drive these hands during a heavy wind is less than 0.001 hp. The motors used have a very large surplus power margin.

Since their conception in 1916 synchronous motor clocks and timing devices have increased in use with extraordinary rapidity, especially during the last few years. According to estimates more than 1,200,000 synchronous motor clocks were sold during 1930. There seems little doubt that during the coming years spring and weight driven clocks will be replaced in large measure by the new a-c. timekeepers, which have proved superior in every important respect.

# Stability Solution for Metropolitan Systems

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**General stability curves are given in this article by means of which the transient stability during fault may be determined for any metropolitan type system. The results are obtained as the permissible fault duration in terms of certain indexes of the system and fault. For a given fault only three readings, taken on a d-c. calculating board, are required, the solution being obtained without the necessity of investigating the electromechanical oscillations.**

STABILITY studies of metropolitan type systems may be profitable not because instability has been a serious operating problem, but because such studies often may permit a more reliable or more economical system layout to be utilized safely. Transient stability, that is, stability during faults, has been found to be the limiting condition for stability of metropolitan type systems, all available information indicating that static instability is never experienced in normal operation of this type of system. Under fault conditions the measure of the degree of stability is the time a fault may be permitted to remain on the system without causing one or more generators to lose synchronism. Curves are presented here which permit the ready determination of the permissible fault duration in terms of certain system constants.

These constants may be found for most metropolitan systems from a short-circuit study on a conventional d-c. calculating board. The fundamental premise underlying this method is that setups giving the same values of the system constants or indexes will have approximately the same degree of stability. The curves give the results of studies on hypothetical systems covering the range of the system constants encountered in metropolitan systems. To render this method practical, the number of indexes must be reduced to a minimum. This means that the variations produced by minor influences must be neglected and average values assumed for machine characteristics. It was found that if the scope were restricted to metropolitan type systems, the number of essential indexes could be reduced to three, with means of modifying these three to provide for the variations produced by the more important influences.

In this discussion a metropolitan type of system is considered to be one in which the principal power sources are generators driven by steam turbines and located relatively close to their load centers, with distribution provided by a large number of moderate voltage circuits. The power supply to most metropolitan districts is of this character, but several large districts receive a major part of their power from distant hydroelectric sources which are quite different in character, and for these, individual studies are required. However, if the hydroelectric generating capacity is one-fourth, or less, of the total,

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Based upon "Generalized Stability Solution for Metropolitan Type Systems" (No. 32-26) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25-29, 1932.

the stability of the other generating sources for faults in their localities still may be analyzed by the methods presented, without serious error.

Metropolitan type systems as above defined are similar in essential characteristics, making generalized studies practicable. The principal features of similarity are as follows:

1. With equal per cent loadings the internal voltages of all generators on the system are practically in phase.
2. Because of the multiplicity of circuits the reactance of the connecting ties holding a generator or group of generators in step with the system does not change appreciably when the fault is cleared.
3. With turbine-generators and short transmission distances, the generator characteristics, no longer being affected by the speed of rotation of the prime mover, line charging current requirements, etc., tend to become fairly uniform in their essential points such as reactances, inertia, and short circuit ratio.

When a fault occurs on a system, all of the generators undergo electromechanical oscillations because of their change in output. Generators which are similarly affected by the fault will react similarly and therefore may be classed as a single unit. In this discussion the term "generator" may indicate either a single machine or a group of machines which react similarly. The most severe faults usually are close to a group of generators and for those cases it is sufficient to consider only two groups of machines, the group most seriously affected or "faulted generator" and the remaining generators.

With the metropolitan type system, the most important factors affecting permissible fault duration are the initial generator output, synchronizing power, and severity of fault. Operation at rated load is the condition usually investigated and this condition has been assumed here, although a factor is introduced to take account of other values of initial load. The remaining two factors may be expressed in various ways, the choice depending upon adequacy and convenience. The index used here for synchronizing power is the over-all reactance between the "faulted generator" and the remaining generators expressed in per cent of the rating of the "faulted generator." The index used for severity of fault is the short-circuit current of the "faulted generator" expressed in number of times rated current, modified if necessary by a factor to take account of fault location.

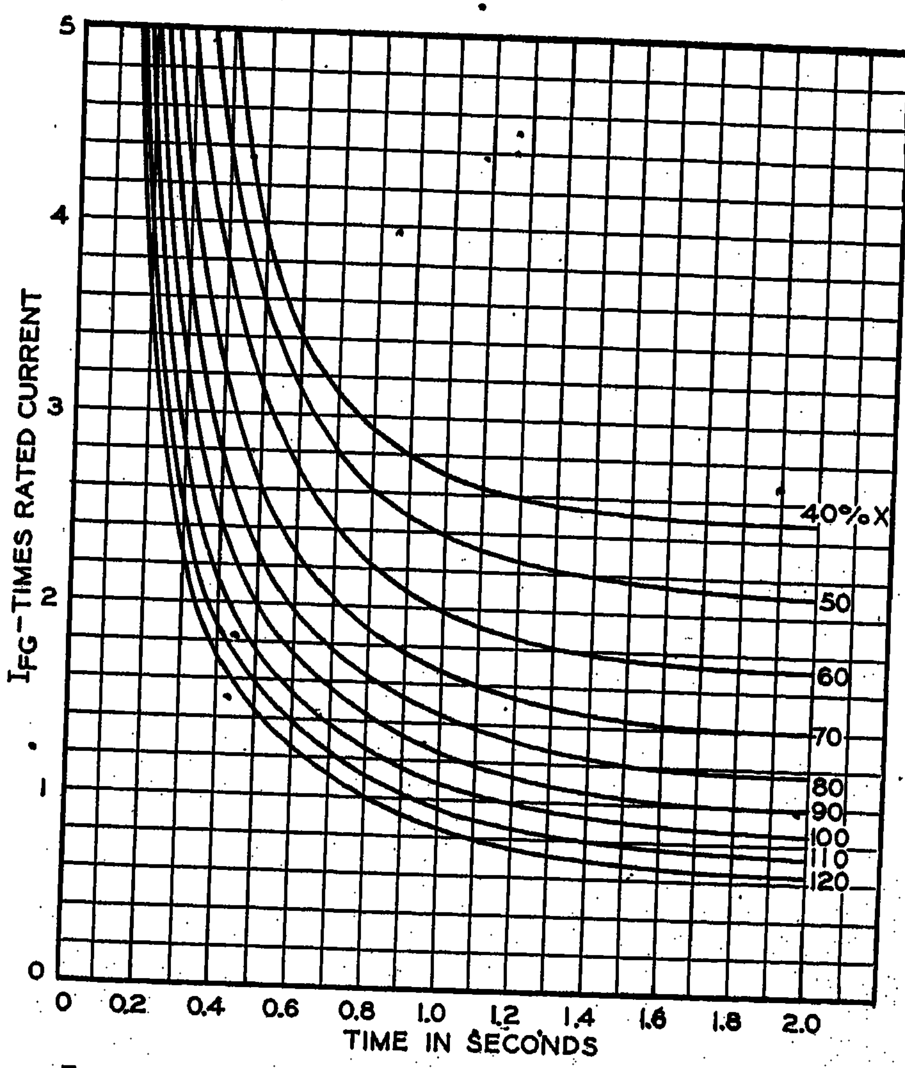

Fig. 1. Principal stability curves. Short circuit current $I_{FG}$ versus permissible fault duration

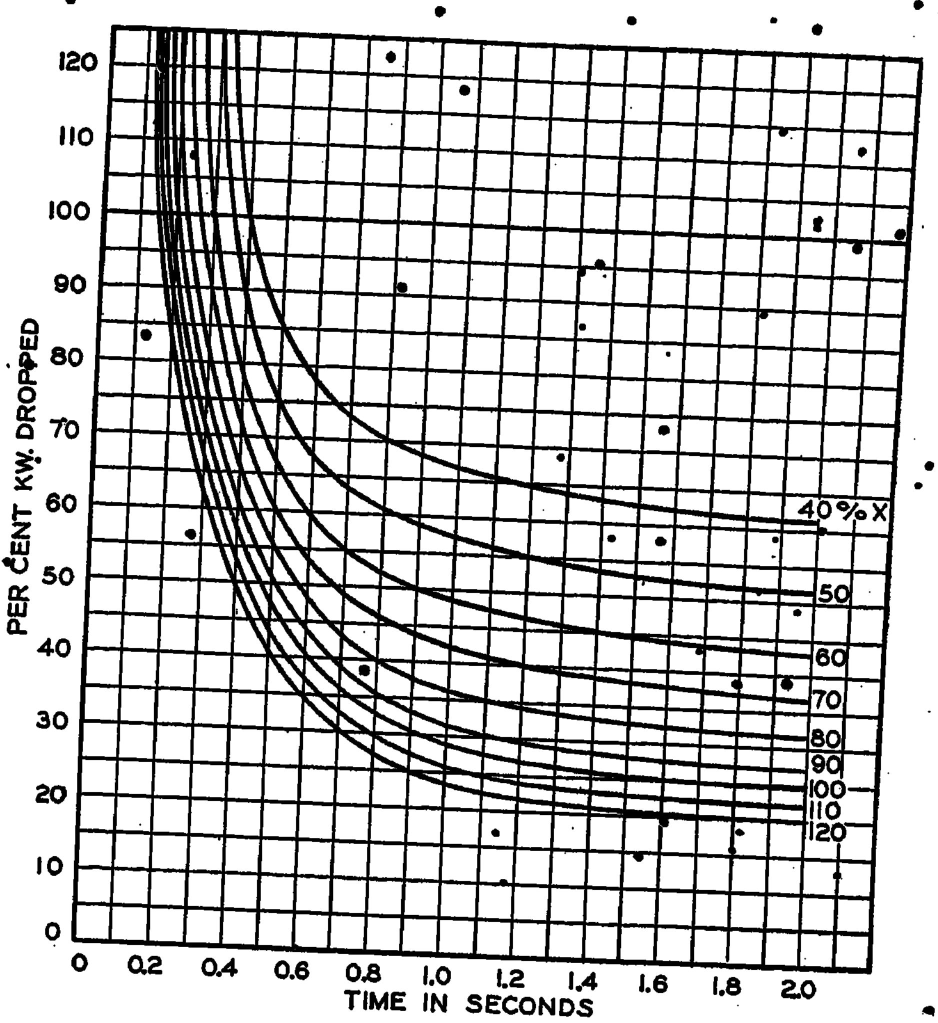

Fig. 2. Auxiliary stability curves. Per cent power dropped versus permissible fault duration

The general stability curves for a generator short-circuit ratio of 1.0 are shown in Figs. 1, 2, and 3. Other curves, not shown, have been calculated for a generator short-circuit ratio of 0.8. These two sets of curves are very nearly identical, and show that generator short-circuit ratio has a minor effect on transient stability. Fig. 1 consists of a family of curves covering the range of over-all reactance $X$ plotted in terms of short-circuit current $I_{FG}$ from the faulted generator, and the permissible fault duration $t$. The curves of Fig. 2, as will be shown later, provide a means of correction for resistance in the fault and for other than rated load on the generator.

The curves of Fig. 1 apply directly to faults at locations electrically equivalent to the generator terminals, such as faults on feeders, just beyond the feeder breaker. To provide for faults occurring at other locations, a close approximation is secured by *dividing* the value of $I_{FG}$ by a factor read from Fig. 3 before entering Fig. 1. This "location factor" is obtained as a function of the ratio of $I_{FG}$ to $I_F$, the total fault current. This ratio will be denoted by $r_{FG}$.

## METHOD OF APPLICATION

The application of these curves will be demonstrated by an example. A typical metropolitan type system is shown schematically in Fig. 4 with reactances as indicated. A fault at point $M$ will be considered. A three-phase fault at this location isolates generator $A$ from the remainder of the system for the duration of the fault, and this generator is therefore the one most likely to fall out of step first. Therefore, machine $A$ becomes the "faulted generator," and all other generators including those in the same group with $A$ become the "remaining generators." Fig. 4 under these conditions reduces to Fig. 5. This reduction may be carried out analytically or by the use of the d-c. calculating board. In the latter case the actual reduction to the simplified form need not be completed, as the necessary indexes may be obtained from the current readings necessary for the reduction. From the simplified figure, the over-all reactance $X$ between the faulted generator and the remaining generators is equal to $27 + 15 = 42$ per cent. This reactance must be based on the kva. rating of the faulted generator in all cases, and if the reactances are set up on some other base they must be converted to this base. To determine the total fault current $I_F$, the branches on each side of the fault are paralleled giving $\dfrac{27 \times 15}{42} = 9.65$ per cent. The total fault current therefore is $\dfrac{1}{0.0965} =$ 10.4 times the rating of generator $A$. The fault current $I_{FG}$ supplied by the faulted generator is $\dfrac{15}{42} \times 10.4 = 3.7$ times rated current. The ratio of $I_{FG}/I_F$ gives $r_{FG}$ as 0.357. The essential indexes are thus

Over-all reactance $X$ = 42 per cent
Current from faulted generator $I_{FG}$ = 3.7 × rating
Ratio $I_{FG}/I_F = r_{FG}$ = 0.357

The location factor is obtained from Fig. 3, entering the curve at $r_{FG} = 0.357$ and interpolating for $X = 42$ per cent, giving a value of 0.7. The adjusted value of $I_{FG}$ is then found to be 3.7 divided by 0.7 = 5.3. The permissible fault duration now may be read from Fig. 1 for $I_{FG} = 5.3$ (extrapolated) and $X = 42$, and is found to be 0.39 sec.

If the d-c. calculating board is used, the indexes may be found directly. With the system set up without the fault, generator $A$ is connected to the positive bus, its transient reactance being included as part of the system, and the remaining generators connected to the negative bus in a similar manner. The current flowing from generator $A$ now is read and converted to number of times rated current for this generator. For this case the value is found to be 2.38. The reciprocal of this value expressed in per cent is $X$ and of course is 42 per cent as before. The remaining generators now are removed from the negative bus and connected to the positive bus and the fault applied by connecting point $M$ to the negative bus. The fault current and current from generator $A$ then are read and converted to number of times rated current of generator $A$. This gives the same result as was obtained from the simplified system of Fig. 5, that is, 10.4 and 3.7 times rated current, respectively.

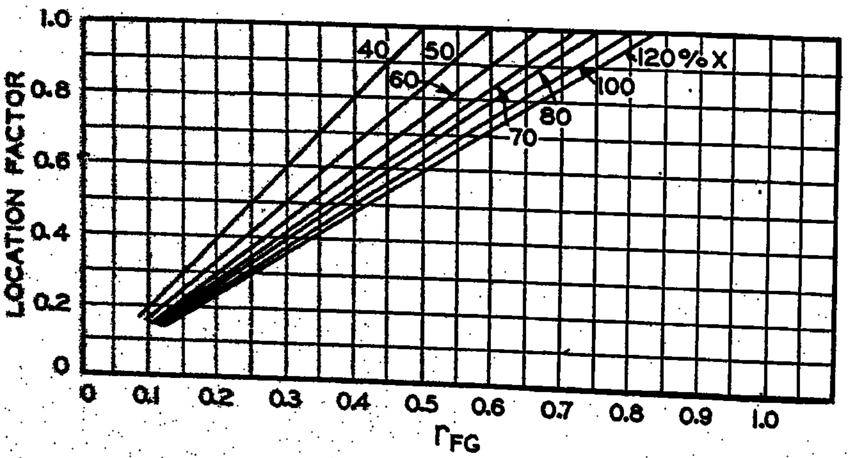

Fig. 3. Location correction factor $r_{FG} = \dfrac{I_{FG}}{I_F}$

If the fault had occurred at point $N$ outside the feeder reactor on a radial feeder instead of at point $M$, the simple equivalent system would appear as in Fig. 6. The reactance of the feeder reactor is assumed as 3 per cent on the feeder rating, equivalent to 30 per cent on the rating of generator $A$, if the feeder rating is one-tenth that of the generator. If the faulted feeder had not been radial and had been tied into the system at the distant end, the equivalent system of Fig. 6 would have been slightly different, although the over-all reactance would still be 42 per cent. It will be found for this case that $r_{FG}$ remains the same since it depends only on the reactance branches adjacent to the generators. Owing to the presence of the 30 per cent reactance in series with the fault, however, the total fault current is greatly reduced and becomes 2.52 times rated current of generator $A$. $I_{FG}$ is found to be 0.9 times rated current and when adjusted for location becomes 1.29. When these indexes are referred to Fig. 1 it is found that the point is beyond the range of the curves and the permissible fault duration is over 2 sec. Two seconds is about the upper limit of relaying time for most systems and the many variables render it undesirable to carry the curves much beyond this figure.

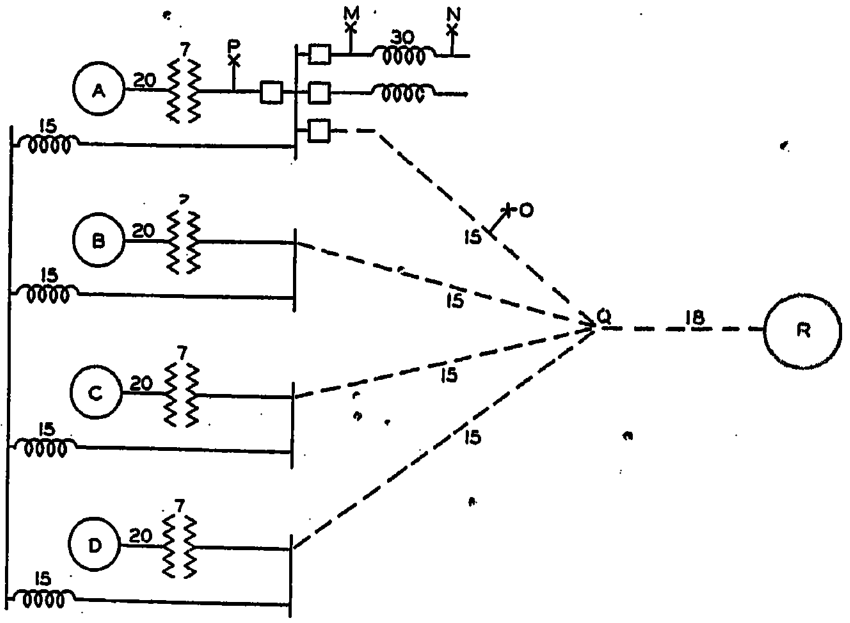

Fig. 4. Typical metropolitan type system

If the fault is at some point $O$ so that it will affect all four of the generators in station $A$ more equally, there is a possibility that this entire group may lose synchronism with the remainder of the system. In such a case, the group should be considered as the faulted generator, and a solution should be carried out expressing all indexes in terms of the rating of the group as a base. This solution should be compared with that for generator $A$ considered as the faulted generator, and the shorter of the two values of permissible fault duration should be taken as the result.

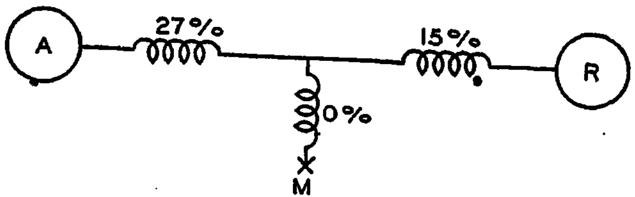

Fig. 5. Simplified equivalent of Fig. 4 for fault at *M*

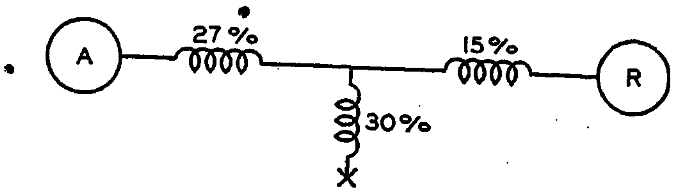

Fig. 6. Simplified equivalent of Fig. 4 for fault at *N*

One more variation will be considered, that of a three-phase fault on the leads of the transformer $A$ at point $P$ close to its bus. In this case generator $A$ obviously must be disconnected from the system in order to clear the fault, and the point of interest is how long this fault may persist without causing generators $B$, $C$, and $D$, to lose synchronism with the remainder of the system. Generator $A$ is isolated from the system by the fault while the fault persists, and is isolated by its circuit breaker when the fault is cleared. Therefore, only machines $B$, $C$, and $D$ are considered as the faulted generator, and generator $A$ is entirely eliminated from the calculations. The equivalent simplified system for this case is shown by Fig. 7, the reactances now being expressed in per cent on the combined kva. rating of generators $B$, $C$, and $D$. From this point the calculations proceed in the same manner as for the previous examples, leading to $X = 94.1$, $r_{FG} = 0.632$ and the adjusted value of $I_{FG} = 1.80$. This gives 0.53 sec. as the permissible fault duration.

If the fault had occurred on the bus, the conditions during the fault would have been the same, but after the fault the tie between the synchronizing bus through the bus of generator $A$ to the point $Q$ is interrupted. This violates the fundamental assumption that the reactance after the fault is essentially the same as before the fault, so that the curves cannot be applied with the same degree of accuracy.

## UNBALANCED FAULTS

The preceding analysis applies directly to three-phase faults. In many cases, however, investigations of unbalanced faults are of interest. The method of symmetrical components shows that from the stability standpoint an unbalanced fault may be represented by an equivalent impedance in series with the fault, the value of this impedance being a function of the negative and zero sequence impedances of the system viewed from the point of fault. These impedances may be found by reducing the negative and zero sequence network either analytically or on a calculating board.

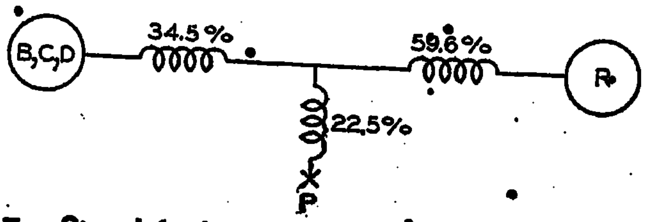

Fig. 7. Simplified equivalent of Fig. 4 for fault at *P*

## CORRECTION FACTORS

The following influences were not considered in setting up the curves of Figs. 1, 2, and 3:

1. Resistance in the connecting lines and in the fault.
2. Values of initial generator load other than normal rating.
3. Voltage regulators.
4. Systems not capable of reasonably accurate representation by two composite generators.

The correction to take these effects into account in all cases shows that the permissible fault duration is as great or greater than would be indicated if the factors were neglected. It is felt therefore that the curves of Figs. 1, 2, and 3 can be used directly without any correction factor for most work. This view is held because for most purposes the limiting cases form the basis of design. A fault of zero resistance and operation at full load give the greatest generator acceleration and therefore lowest indicated stability. Where systems do not reduce to two composite generators, the stability will be as high or higher than when they do. Voltage regulators of course increase the stability. Therefore if the curves are used directly, without correction factors, the error will be on the safe side. It is appreciated, however, that in some cases the effect of these variations on stability is of interest in system planning and operations, and approximate corrections have been set up to take care of these cases. Each of these variations has been investigated analytically, and in some cases extensive calculations were necessary to determine their effect on stability. However, since it was considered most important that the correction factors be easily applied, some liberty in accuracy was taken in formulating a method of applying the corrections. It should be understood therefore that the correction factors now to be described differ somewhat from the theoretically correct values. They are arranged approximately in the order of their importance. Correction factors affecting the value of $I_{FG}$, if used should of course be applied first.

## RESISTANCE

Resistances of the ordinary range have a minor effect on stability, with the exception of resistance in the fault circuit; that is, those branches carrying the greatest proportion of fault current. Due to the large currents in the fault circuit, a relatively small amount of resistance will result in a considerable power loss. This power loss compensates in a large measure the drop in load on the faulted generator due to drop in voltage, so that the tendency to pull out of step is minimized. Both Figs. 1 and 2 are plotted for faults at the generator terminals. Application of the location factor from Fig. 3 converts a fault at any other location to its equivalent fault at the generator terminals. For each point in Fig. 1 there is a corresponding point in Fig. 2, from which may be found the amount of power required to be dropped by the faulted generator for the equivalent fault at its terminals. If the amount of power dropped is reduced by the presence of resistance in the lines or fault, the effect would be nearly the same regardless of fault location. Hence the result may be found by reducing the equivalent amount of power dropped by the amount of the resistance losses taken by the faulted generator, and reading the corrected value of fault duration from the proper reactance curve of Fig. 2.

In the example previously considered for a fault at $M$ with $I_{FG} = 5.3$ and $X = 42$, a clearing time of 0.39 sec. is indicated by Fig. 1. The same clearing time must be indicated by Fig. 2, hence, for $X = 42$ and $t = 0.39$, it is found that 100 per cent power would have to be dropped by the generator during the fault if the fault were at its terminals. The curves have been drawn by plotting this power as per cent of the generator kw. rating, which is 85 per cent of the kva. rating. Now suppose generator $A$ and its transformer have a total resistance of 1.5 per cent on their rating; with 3.7 times full load fault current flowing, the $I^2R$ loss in the generator and transformer is $3.7^2 \times 1.5$ per cent or 20.5 per cent of the generator kva. rating, or 20.5 per cent divided by $0.85 = 24$ per cent of its kw. rating. Then instead of the 100 per cent load dropped if the generator and transformer had zero resistance, the equivalent load dropped is 100 per cent minus 24 per cent or 76 per cent. The permissible fault duration, considering the effect of resistance, is then found from Fig. 2 for $X = 42$ per cent, and power $= 76$ per cent, and indicates a permissible fault duration of 0.6 sec.

In the example given above, the resistance in only the generator branch of the equivalent circuit was considered. The power loss was then easily determined, and was all supplied by the faulted generator. If the fault is located at some point on the system where there is a number of paths in multiple for the flow of fault current, the power loss may be determined by adding the $I^2R$ loss in the various branches between the fault and the generator. The currents in the branches may be obtained by measurement of current in corresponding branches of the d-c. calculating board. They may then be squared and multiplied by the per cent resistance of the branches, and added to get the total power loss due to the fault.

If resistance in the fault itself is to be considered, the power loss in the fault must be apportioned between the faulted generator and the remaining generators. An approximate method of doing this is to multiply the total loss in the fault by the ratio $r_{FG}$, and add this value to the loss in the generator branch of the fault circuit, if this is considered. As an example, for a fault at $M$ assume $^1/_2$ per cent resistance in the arc of the fault, in addition to the resistance of the generator and transformer. With 10.4 times normal current, $10.4^2 \times 0.5$ or 54 per cent of generator kva. in power is created in the arc. This is equivalent to 54 per cent divided by 0.85 or 63.5 per cent of generator kw. rating. Multiplying by $r_{FG}$, 63.5 per cent $\times\ 0.357 = 22.5$ per cent power in the fault, taken by the faulted generator. The power dropped is 100 per cent for $X = 42$ per cent, and $t = 0.39$ sec. When 24 per cent due to generator and transformer resistance and 22.5 per cent due to fault resistance are subtracted, 53.5 per cent remains as the equivalent power dropped. This value of power dropped is seen from Fig. 2 to give a permissible clearing time in excess of 2 sec.

## Initial Generator Load

For values of initial generator load other than 100 per cent of kilowatt rating, first find the value of kilowatts dropped, corresponding to $X$ and $t$ for rated initial load. Multiply this by the ratio of initial load to full load, and read the corrected clearing time from Fig. 2, for the curve corresponding to $X$. Example: with $X = 42$ per cent, $t = 0.39$ sec., 100 per cent kw. is dropped; if the initial load had been 75 per cent instead of 100 per cent, the approximate fault duration may be read as $t = 0.61$ for kw. dropped $= 100$ per cent $\times\ 0.75 = 75$ per cent and $X = 42$ per cent.

## Voltage Regulators

Voltage regulators with a moderate rate of excitation response will give a certain amount of improvement in stability over the values given by Figs. 1, 2, and 3. The precise amount is difficult to determine, but from calculations made, assuming a rate of response sufficient to maintain constant flux in the generator field, a reasonable idea of possible improvement may be obtained. The results of these calculations when compared with the standard curves without voltage regulators show that over most of the range the improvement can be approximated by multiplying the value of $I_{FG}$ by 0.85 before entering the curves of Fig. 1.

## Different Types of Systems

The curves of Figs. 1, 2, and 3 theoretically are applicable only to systems connected essentially in star form, typified by the synchronized at the load method of connection. This is because the simplified systems which were analyzed in obtaining these curves were of the star form. However, analyses were made also of the ring connection, which represents the maximum possible deviation from the star connection, and the results of these analyses did not differ very greatly from those of the corresponding star systems. Hence, although certain variations will occur in special cases, no correction factor to take account of system connection is required for most work.

GENERAL COMMENTS

The results obtained from these curves, as is to be expected, will have the same order of accuracy as results obtained by a specific analysis of the actual system using the assumptions conventionally made to simplify the work. Further, experience and test have shown that actual systems have greater stability than the usual calculations indicate. This fact should be borne in mind when using the curves for relay settings or system design, and in general, no additional margins of safety need be allowed.

The greatest value of these curves probably lies in the facility with which they allow comparative studies of different layouts to be made. When used in this way the margins between actual and calculated values of stability are largely compensating and therefore need be of little concern except in extreme cases. Sufficient knowledge concerning load and machine characteristics, particularly those factors affecting damping, is not available at present to determine the margins with precision even as a result of the most careful and involved calculations; so that the curves presented here may be used in all cases where they apply until further data have been obtained on hitherto unevaluated factors.

# Engineering Lights the Darkness

**Shall mind or matter be fostered? In either case, engineering is lighting the path and will continue to light the way of the coming generation. This is the ninth article of the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"**

By
A. P. GREENSFELDER President, Associated Genl. Contractors of America

DARKNESS is of two kinds: physical the absence of light, and mental the absence of knowledge. Engineering multiplies the means for the earlier relief of both varieties. To create these means is one of the functions of the engineer.

Turning night into day at first seemed sacrilegious. Other steps in scientific and engineering progress have shocked or scandalized many persons in the years that have gone, but they have come to be accepted matters of course. With the discovery of fire came the consciousness that human eyes could see in the firelight as well as in the moonlight. The history of illumination is truly romantic, the firebrand, the torch, animal oil, the candle, mineral oil lamps, gas, and successive steps in electrical illumination marking the accelerating steps in better lighting. Now, television causes no more violent agitation than a few ripples of public interest.

How has man utilized the lengthened day? First, to dispel the fears lurking in the darkness; next to light his path of travel; and then to permit recording and reading current historical events and accentuating religious ceremonies; later, to foster amusement after the hard day's hunting, tilling of the soil, or the fighting of battles; and finally, to extend the opportunities for education, commerce, and social intercourse.

The discovery of window glass changed the design of structures for man's habitation. Sunlight, by penetrating interiors, dispelled dampness and disease. The modern lighthouse and the city's show windows are wonderful combinations of glass and artificial lighting; one promotes safety at sea, and the other adds to the attractiveness of marts of trade. Speed of night transportation depends absolutely upon the engineering application of light; locomotive, vessel, and automobile headlights, signal systems, and the illumination of highways and airports are all vital necessities.

Modern buildings now go to two extremes, walls of glass and windowless walls. Conservation of daylight and complete control of illumination by exact diffusion of electric light both have their places. The "great white ways" of our cities are just signs of our times. Steam turbine power stations, hydroelectric plants, interconnected transmission lines, all bespeak engineering achievements.

INTELLIGENCE

The dispelling of mental darkness is even more vital to "life, liberty, and the pursuit of happiness" than is the conquering of physical darkness. The use of "midnight oil" has produced world leaders. Rubbing the lamp of the fabled genii produced small wonders compared to the modern miracles of man.

Whither our way? Shall we foster mind or matter? Shall we add to the mounting volumes of books or of buildings? How should they be correlated?

We talk today of over-production. We lament over-expansion of facilities for the production of goods. Then why not more homes and schools and hospitals, and better highways to make them accessible, bridges to span the gaps of time as well as space, the sowing of ideas as well as seeds?

Production is threefold: articles to be consumed, wealth in private structures, and community facilities. Engineering minds constantly are eliminating wastes of production. By steadily improving railroads, highways, and other means for carrying goods, they have brought costs of transportation to amazingly low figures compared with those of pre-railroad days. Now with even greater concentration, engineers should devote energy to reducing wastes of distribution. Engineering methods, properly utilized by business men, should be helpful in reducing the costs of merchandising just as they have been helpful in cutting costs of producing goods, power, and light. Engineers will be found ready to cooperate in solving the problems of merchandising.

Engineering analysis is forecasting the future—lighting the paths which our children will follow. Engineering talent must and will aid in directing the tendencies of the time. Perhaps more schools and fewer smoke-stacks, more fine community edifices and fewer factories, more leisure and more light, are the present needs of our people.

**Editor's Note: Pursuant to the invitation of The Engineering Foundation, the editors will be happy to receive comments, criticisms, or discussions pertaining to this or the other articles published in this series.**

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# Electrochemistry and Electrical Engineering

**Electrochemical and electrometallurgical industries in the United States are said to consume a considerable percentage of the total annual electric power output for the entire country. The fundamental electrochemical processes are discussed in a general way, with typical examples given for each general case.**

By
G. W. VINAL
MEMBER, A.I.E.E.

Bureau of Standards,
Washington, D. C.

IMPORTANCE of electrochemistry and electrometallurgy in the broad field of electrical engineering can be realized best when it is considered that (1) these processes furnish basic materials for manufacturing processes; (2) installed operating capacity of these industries is large and increasing yearly; (3) a vast army of workers is employed in these industries which produce outputs valued at several billions of dollars; and (4) electrochemistry and electrometallurgy present a promising field for future developments. Quoting from the 1930 annual report of the A.I.E.E. committee on electrochemistry and electrometallurgy:

> "There are many who feel that the electrical industry is more in need of increased outlet for power than of further small gains in the efficiency of electrical apparatus *per se*, and that the great body of expectant young electrical engineers must look for adequate opportunities for advancement more to the fields of utilization and electrical processes than to the conventional ones (fields) of apparatus and generation."

Before proceeding further with the discussion, definition of the term electrochemistry together with some indication of its breadth may be in order. Electrochemistry in a general way may be defined as that branch of science and technology which deals with reciprocal transformations of chemical and electrical energy. Closely related to electrochemistry is electrothermics, dealing with chemical effects produced by heat from applied electrical energy. Closely related also is electrometallurgy which deals with the application of electrochemistry or electrothermics to the extraction or treatment of metals.

The quantitative relationship between the amount of electricity passing through an electrolytic cell and the chemical effects which are produced is expressed in Faraday's laws of electrochemical action. The year 1933 marks the centenary of this great discovery by Faraday.

Electrochemical processes differ from many other applications of electric power in that a power supply of rather low voltage per unit is required, but at the same time one which is capable of delivering large currents. Because of the large currents required one of the principal problems involved is that of limiting the power loss between the power supply and the point of utilization. The provision of automatic control for electrochemical processes presents another problem with which the engineer engaged in this field is confronted; this of course is complicated also by the high current and low voltages employed. Still another problem arises in the provision of suitable insulation in apparatus for use in wet processes, especially those involving acids, caustic solutions, or fumes.

## USE OF ELECTRICITY FOR DEPOSITING METALS

One of the principal processes for depositing metals by electricity is that known as electrowinning. In this process metals or compounds are deposited from

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Written especially for ELECTRICAL ENGINEERING, and based upon a lecture delivered during the electrochemistry and electrometallurgy session of the A.I.E.E. winter convention, New York, Jan. 28, 1932. *Not published in pamphlet form.*

solutions derived from ores or other materials using insoluble anodes.

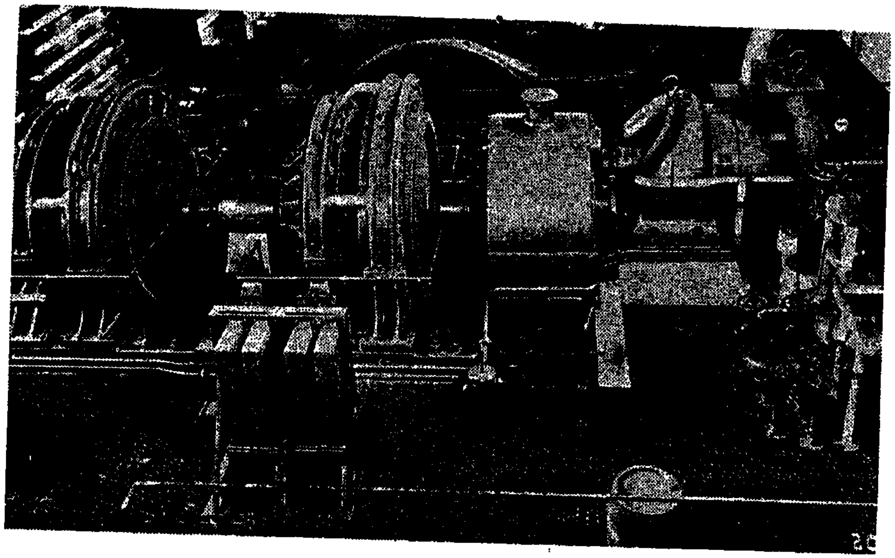
One of the more recent developments of this nature is the electrowinning of zinc. Principal advantages of this method of producing zinc are (1) the higher purity of metal produced (about 99.99 per cent pure), (2) the more complete extraction of the ore, (3) the fact lower grade concentrates are usable, and (4) materials often lost in other processes are recovered. The raw material used is a flotation concentrate of from 19 to 58 per cent zinc. This is subjected to a roasting process to eliminate the combined sulphur dioxide; the resulting calcined product then is leached with sulphuric acid, the solution purified, filtered, and finally electrolyzed by passing a direct current through it. Principal by-products of this process are, sulphuric acid and metallic cadmium. Other by-products which at the present time are lacking a market are germanium, thalium, indium, and gallium.

Besides its application to the production of zinc, the electrowinning process is applied also to the production of other metals, notably copper, and to a less extent lead, tin, nickel, cadmium, and iron.

## ELECTROREFINING OF METALS

Another deposition process which is of great importance is the electrorefining of metals. This consists essentially of the cathodic deposition of pure metal from the anodic solution of crude metal. The most important commercial process of this type is the electrorefining of copper, the estimated aggregate capacity of eight large plants in the United States being about 3,000,000,000 lb. yearly.

Copper produced from the smelter contains small percentages of other metals, such as gold and silver. To produce the exceedingly pure grade of copper required for electrical purposes and at the same time to recover the silver and gold, the smelter product is refined by electrochemical methods. In a typical large plant the operation is carried out as follows:

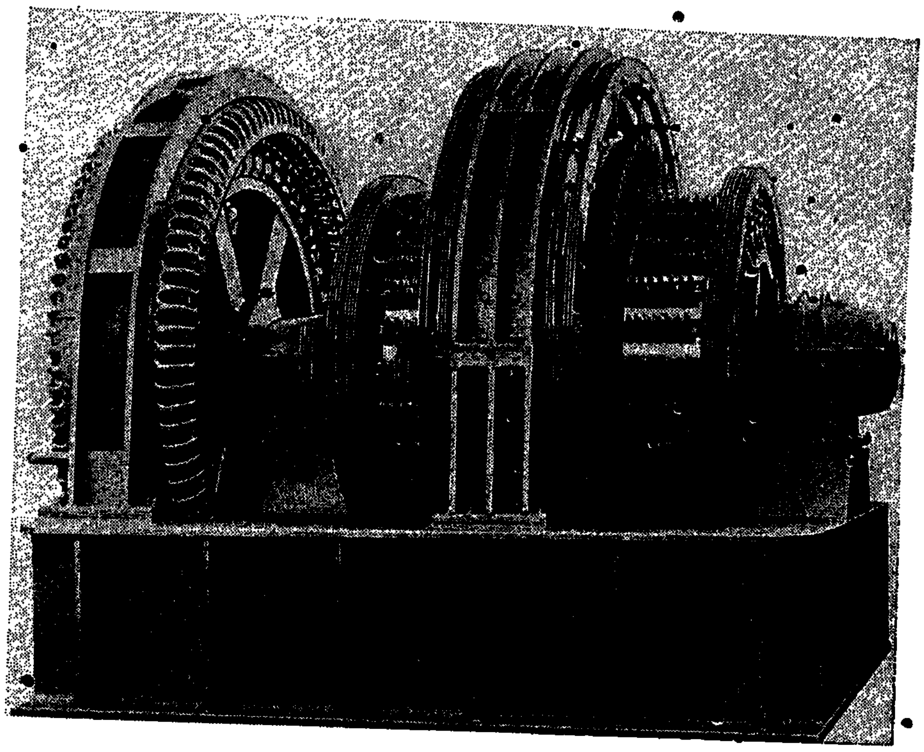


Courtesy of Westinghouse E. & M. Co.

Fig. 1. A pair of d-c. generators driven through a 10/1 reduction gear by a 3,600-r.p.m. steam turbine. Each generator is rated at 11,200 amperes, 140 volts

1. Blister copper obtained from the smelter is first melted and cast into anodes.
2. These anodes are immersed in an acid copper sulphate electrolyte; current passed through the electrolyte deposits the pure copper on the cathode.
3. Cathode copper is melted and cast into commercial shapes.

Current density used in this process (step No. 2) varies from 15 to 25 amperes per sq. ft. of cathode surface. The efficiency of the process is about 95 per cent, according to Faraday's law. Power supply for this refinery is obtained from turbine-driven generators having a total output of 12,500 kw. at 2,300 volts, 60 cycles. Power is transmitted to the tank house at this voltage where it is converted to low voltage direct current by motor-generator sets. The current passed through each tank is approximately 8,000 amperes, at a d-c. potential of 0.25 volt per tank.



Courtesy of Hanson, Van Winkle, Munning Co.

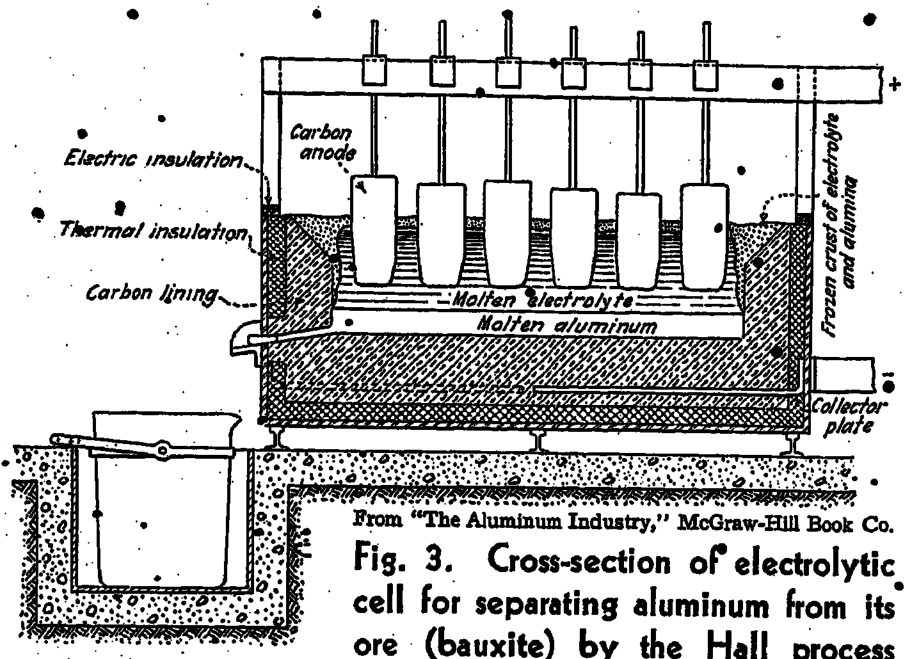
Fig. 2. Typical motor-generator set used for electroplating. Generator is rated at 10 volts, 25,000 amperes. Note commutator and multiplicity of brushes

Copper refined by the electrolytic process is characterized by its high purity, 99.98 per cent. Other metals refined electrolytically include antimony, bismuth, gold, iron, lead, nickel, silver, and tin.

Electrolytic refining of metals is a purification process which may be justified even though the per cent gain in purity may appear relatively small. The anode of crude metal may be more than 99 per cent pure but the elimination of a fractional per cent of impurities makes significant changes in physical and chemical properties. In typical cases, the refined metal is softer, has a higher electrical conductivity, is more resistant to some kinds of corrosion.

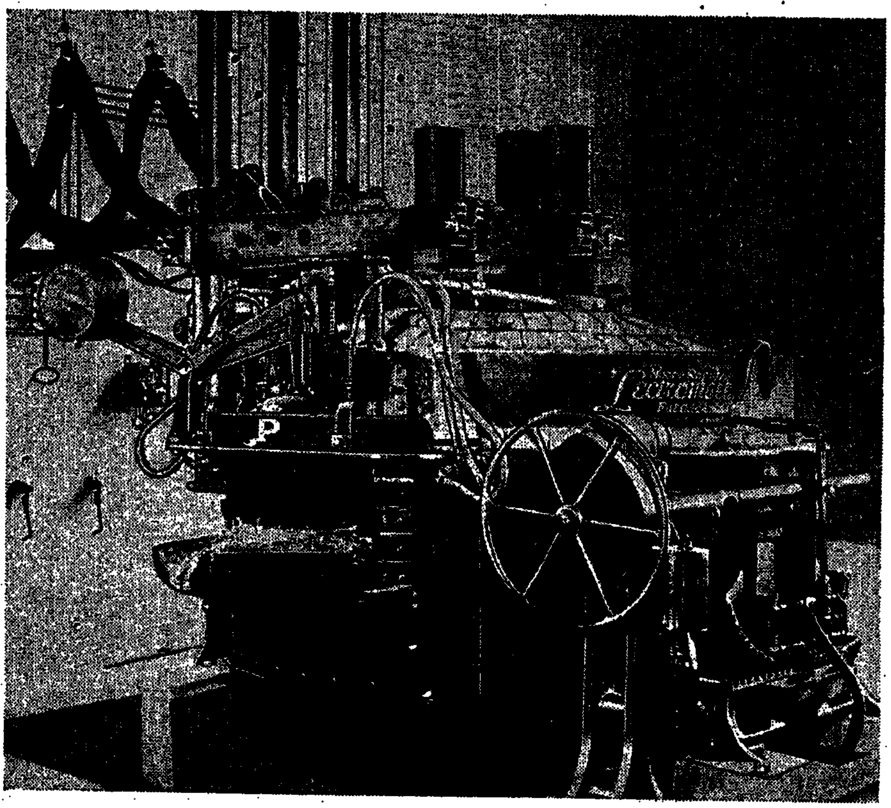
## ELECTROPLATING AND ELECTROFORMING

Electroplating is another electrodeposition process of considerable importance. In general, electroplating may be said to be the electrodeposition of an adherent coating upon an electrode for the purpose of



From "The Aluminum Industry," McGraw-Hill Book Co.

**Fig. 3. Cross-section of electrolytic cell for separating aluminum from its ore (bauxite) by the Hall process**



Courtesy of W. E. Moore & Co.

**Fig. 4. A three-phase electric arc furnace having a capacity of three tons per hour**

securing a surface with properties or dimensions differing from those of the base metal. The specific object for which plating is carried out may be ornamentation, resistance to wear or corrosion, reflecting power, increased dimensions, or other factors.

Of great interest and importance at the present time is the process of chromium plating. This was accomplished first about 70 years ago, but the past few years have witnessed an intensive development. Principal properties of chromium which are of interest in connection with its use in plating are its extreme hardness, low ductility, resistance to tarnish, and reflecting power, which is about 65 per cent (compared to 95 per cent for silver). For best results the thickness of a chromium coating is usually between 0.00002 and 0.00004 in.; thicker coatings tend to crack and peel. For best results the chromium usually is applied over a preceding metal plating, preferably either copper or nickel.

The bath used in chromium plating is chromic acid with the addition of chromium sulphate or carbonate. For the anodes, lead or iron are used; bath temperature ranges from 40 to 60 deg. cent. In this connection it may be mentioned that the "throwing" power of chromium is relatively poor. By this is meant that the ability of the metal to distribute itself evenly over an uneven cathode surface is less than that of many other metals.

In regard to the power requirements for chromium plating, a bath voltage of from 6 to 12 volts is needed (a rather high figure for plating). The current density required is from 100 to 300 amperes per sq. ft. of cathode surface. The resultant "electrolytic" efficiency is rather low which together with the valence of 6 at which chromium is deposited makes the cost of current for chromium plating rather high, in fact it is about fifteen times that for an equivalent amount of nickel plating, but less chromium generally is used.

Other electroplating processes, some of which are more or less well known, are cadmium, copper, gold, lead, nickel, silver, tin, zinc, some alloys, and even rubber. Recently some success has been attained in electroplating aluminum. Rubber, unlike the metals, is deposited at the anode and not the cathode.

Electroforming is still another type of electrodeposition; this process is used for the production or reproduction of articles. Included in this class of processes are electrotyping; reproduction of engravings, medals, and phonograph matrices; and the making of seamless tubes. The process provides an extremely accurate method of reproducing a metallic surface, and it is said that lines 0.00002 in. wide can be reproduced faithfully. Metals commonly used in these operations are copper, nickel, and chromium.

## ELECTROLYSIS OF FUSED ELECTROLYTES

Electrolysis of fused electrolytes is a process employed for the electroseparation of certain metals from ores or compounds in the fused state. One of the most common metals separated from its ore in this manner is aluminum. Although aluminum is the most widely distributed of the metals in nature, its commercial use has become possible only in recent years, largely as a result of the electrochemical process introduced by Hall. This process consists of simply passing a direct current through a molten bath of cryolite ($Na_3AlF_6$) containing dissolved aluminum oxide ($Al_2O_3$).

The electrolyzing of the molten bath is carried out in specially designed cells sometimes called electrolytic furnaces or "pots." (See Fig. 3.) For anodes carbon blocks are used, these being mounted in the tops of the cells. Aluminum in liquid form is separated by the action of the current passing through the molten bath, and is deposited in the bottom of the cell on the carbon lining which serves as the cathode. The anodes waste away gradually with the formation of carbon monoxide; the fused aluminum is protected from oxidation, however, by the fused cryolite immediately above it.

In commercial plants usually from 30 to 100 cells are connected in series. The potential required per cell is from 5 to 7 volts, the current requirement being from 8,000 to 30,000 amperes. From 10 to 12 kw-hr.

of electric energy is required per pound of aluminum produced, with a resulting operating efficiency of from 75 to 90 per cent. In this connection it should be noted that the continuity of power service in a plant producing aluminum by this method is quite essential, for if a cell becomes frozen the contents must be dug out, the material is wasted, and the cell must be relined. Purity of the aluminum produced in this manner is about 99.7 per cent.

For aluminum of higher purity, the Hoopes process for refining sometimes is used. This operation is carried on in specially designed cells also, but in this case the anode is at the bottom. Aluminum to be refined is a liquid alloy upon which is molten electrolyte, with the pure cathode aluminum at the top of the cell. The resulting product, which has a purity of better than 98.98 per cent, is relatively soft, possesses high electrical conductivity, and is resistant to corrosion.

Other metals separated from their ores or otherwise treated in the fused state by electrolysis, are magnesium, sodium, calcium, lithium, cerium, and beryllium. Beryllium is a metal lighter than aluminum, is hard and brittle, and is resistant to tarnish, but at present is not widely used.

## ELECTROLYSIS OF BRINE AND HYDROXIDE SOLUTIONS

Electrolysis of brine and hydroxide solutions is carried out in large electrolytic cells, a direct current being passed through the solutions between suitable electrodes. Some of the more common products of these processes are chlorine, hypochlorites and chlorates, caustics, hydrogen, and oxygen. Alloys of sodium also are produced in this manner in certain types of cells.

Chlorine has many uses, some of the more common being in the paper and textile industries for sanitation purposes, for the manufacture of poisonous gases, and in the formulation of synthetic organic compounds of which carbon tetrachloride is a familiar example. Hydrogen is used in the manufacture of synthetic ammonia, in the hydrogenation of oils, in atomic hydrogen welding, and in other well-known processes.

As regards the economic considerations involved in the production of gases by electrolysis, oxygen produced electrolytically must compete with that obtained by fractional distillation of liquid air. Electolytic hydrogen also competes with that obtained by other methods. There are many ways of producing hydrogen which vary greatly in cost. In most cases, however, low cost of production is offset, at least in part, by the cost of subsequent purification. Hydrogen produced by electrolysis has a purity of from 99.5 to 99.9 per cent, and this is the only method in which purification is not generally necessary. Thus it is obvious that although the cost of producing the gas may be somewhat higher by the electrolytic method, the total cost of the gas when other methods are used, including purification, is such as to make the electrolytic method attractive, particularly if there is a market for the other products of electrolysis that go with it.

In a plant recently described, units of 140 cells each are used, these being connected in series. Current and voltage requirements are respectively 2,500 amperes and 700 volts (5 volts per cell). Each unit produces 5,500 cu. ft. of hydrogen per hour.

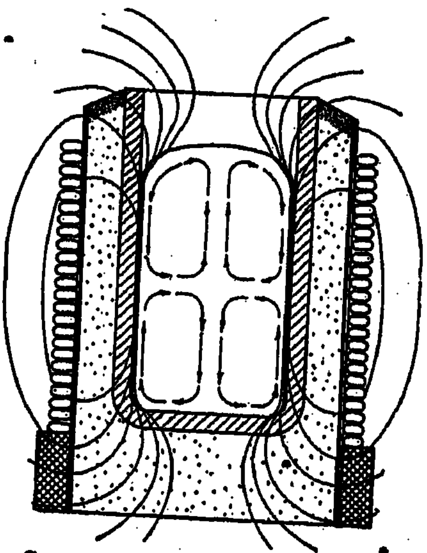
## ELECTRIC FURNACES AND ELECTROMETALLURGY

Temperatures higher than those obtainable by combustion methods are required in the manufacture of many electrochemical and electrometallurgical products. In such cases, heating by electricity finds a ready application. In general, electric heating possesses greater flexibility of application than heat obtained from gas or solid fuel combustion. This means that heat produced from electricity usually can be developed at or adjacent to the point of use more rapidly and effectively than when fuel is used, with the further advantage that smoke, ashes, and fumes are absent.

In many electrometallurgical operations heat is applied to the material undergoing treatment in an electric furnace, of which there are various types. The electric furnace, however, is not inherently an efficient device, and special care must be exercised so that the electric energy will be applied properly.

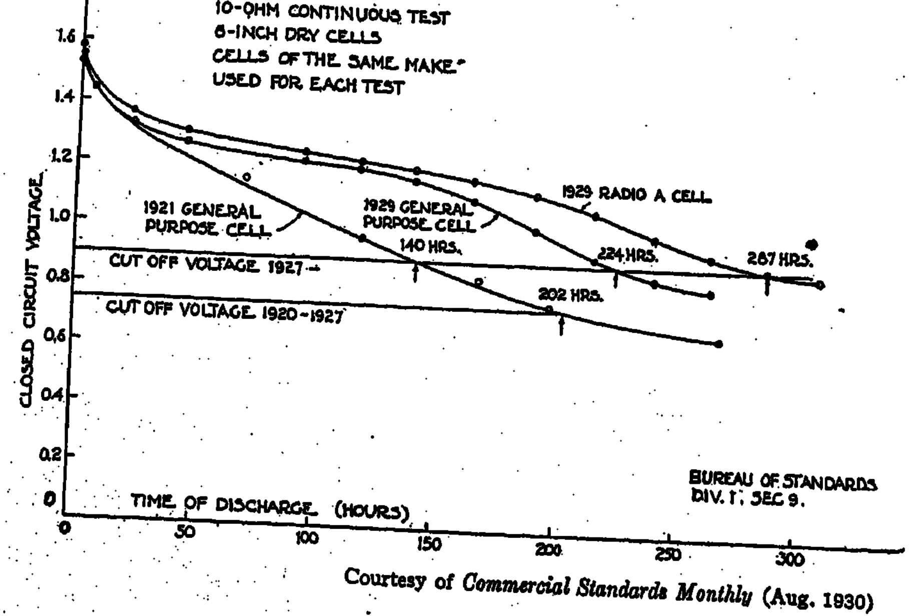
In resistance furnaces heating is accomplished by electric current (either a-c. or d-c.) passing through some resistant material which may be either the reacting substances or a resistor from which heat is imparted to the reacting substances. One of the typical uses for the resistance furnace is in the manufacture of carborundum. In this case the current passes through a core surrounded by silica ($SiO_2$) and

**Fig. 5. (Right) Diagram of induction furnace showing magnetic field and stirring effect produced in the charge by eddy currents**



Courtesy of Ajax Electrothermic Corp.

**Fig. 6. (Below) Curves illustrating improvement in commercial dry cells; output is shown for same brand of cell in 1921 and 1929**



Courtesy of *Commercial Standards Monthly* (Aug. 1930) carbon. The reaction is such that the silicon and carbon combine to form carborundum (SiC) and carbon monoxide.

Another common type of electric furnace now in use is the arc furnace which is used principally in the iron and steel and ferro-alloy industries. Arc furnaces may be subdivided into two general types: (1) that in which the arc occurs between the electrode and substance undergoing treatment; and (2) that in which the arc occurs between electrodes. Ferro alloys represent an important product of this class of electric furnace. These include not only alloys which are suitable for producing steels having certain definite properties, but also alloys such as ferro silicon and ferro manganese which are used for cleansing and deoxidizing purposes in the manufacture of such steels.

Another important kind of electric furnace is the induction type. These furnaces are used on alternating current only. The first variety of these consists essentially of a transformer with a single short-circuited turn as its low voltage winding, this turn formed by the material undergoing treatment. The second type is known as the high frequency induction furnace, in which eddy currents are induced in the charge or crucible. (See Fig. 5.) These eddy currents produce the heat. Induction furnaces have found their widest application in non-ferrous metallurgy, but recently some of the high frequency furnaces have been used for melting special alloy steels. The size of induction furnaces has been increased recently and high frequency furnaces having a capacity of four tons are now in use.

### BATTERIES

Perhaps the most common electrochemical application to the average electrical engineer is in connection with electric batteries. The well-known dry cell is a common example of primary battery and requires no further introduction. It may be of interest to note, however, that the efforts of research and testing have borne fruit in this field, as well as in others, and have resulted in the production of cells of greatly improved quality. This is brought out in Fig. 6.

Storage cells or accumulators also are familiar to the average electrical engineer and in general need no further description or explanation. They provide a portable source of power, or a dependable reserve source of power, and are applicable in cases where other power sources are lacking, as in farm-lighting plants and in submarines. The weight of storage batteries represents their principal limitation. Theoretically 12 ampere hr. per lb. per cell might be obtainable, but the present practical limitation is about half that figure.

### CONCLUSION

Treatment of the subject matter of this article necessarily has been generalized in nature. That it would be impossible in an article of this length to give any detailed treatment of a subject embracing such a wide field of activity as electrochemistry, is quite obvious. Nevertheless, electrochemical and electrometallurgical operations have been demonstrated to be a fruitful field for the application and utilization of electric power. For this reason alone the subject should be of interest to electrical engineers in general, and especially to the great body of expectant young engineers. Development of new materials and processes, however, based upon the utilization of this power is a field requiring talent of high order; but at the same time it is one which should prove extremely attractive to men of electrical training who can and will superpose upon that training a knowledge of the fundamentals of chemistry.

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# Heart Injury From Electric Shock

**Experiments and observations show that the heart is especially susceptible to injury from electric shock. Using experimental animals, measurements of heart currents showed that about 10 per cent of the total "shock" current actually flowed through that organ.**

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STUDIES of the effects of electric shock upon rats indicated that the injury in most cases was confined to that portion of the body which was traversed by the current. (A.I.E.E. JL., V. 49, Jan. 1930, p. 25–9; A.I.E.E. TRANS., v. 49, 1930, p. 381–94 and v. 50, 1931, p. 1165–70; *Elec. Jl.*, v. 28, 1931, p. 472.) Accordingly a series of experiments was instigated to determine the effect upon the heart, since this organ is believed to be especially susceptible to injury from this source. As the extent of the injury is believed to be proportional to the amount of current flowing, experiments were directed toward determining the actual current flowing

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Written especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

through the heart when contact with a circuit was made at various parts of the body.

Because the ventricles of a dog's heart are readily thrown into a permanent state of fibrillation by the application of a relatively weak current, as is the case with man, dogs completely anaesthetized with morphia and ether were used in the investigation. By ventricular fibrillation is meant the failure of the ventricles of the heart to beat with a coördinated rhythm; under this condition all individual muscle fibers of the heart contract asynchronously and accordingly no blood is circulated by that organ.

## MEASURING THE HEART CURRENTS

Many interesting features were involved in measuring the current through the heart, but it was somewhat simplified by the fact that as a source an ordinary 60-cycle a-c. circuit was used. After some preliminary experiments, it was decided to measure the current by means of a ring or through type current transformer with the heart itself forming the primary conductor. If made small enough, a device of this kind could be introduced into the chest and surround the heart without seriously disturbing natural conditions. For the cores of these transformers the highest quality magnetic material was used. (The authors wish to take this opportunity to thank the Bell Telephone Laboratories, Inc., and the Westinghouse Electric and Manufacturing Company for their kindness in furnishing the cores.) These cores were ring shaped and had approximately a square cross-section with an area of 0.01 sq. in. These transformers were made up in various sizes from $^5/_8$ in. to 3 in. in diameter, for use with different sizes of hearts as found in different animals.

Each transformer core was thoroughly insulated with varnish, after which the secondary windings, consisting of No. 36 B&S gage silk-covered wire, were wound on by hand, great care being exercised to wind closely and uniformly. Each transformer core was wound with a whole number of layers, with the result of course that different transformers had different numbers of turns, these varying from 1,500 to 2,500. This introduced no difficulty, however, as each transformer was calibrated separately.

In making measurements the terminals of the transformer secondary winding were connected across a potentiometer type rheostat, and the desired portion of potential drop fed into a vacuum tube amplifier; the output of this amplifier was a measure of the current flowing through the heart. Complete details of this electrical equipment are published elsewhere (*Rev. Sci. Instr.*, v. 2, p. 541, 1931).

Operation of these transformers was carefully checked using a conducting bath of sodium chloride solution as the primary or central conductor; the bath was of such dimensions as to insure uniform current density at its center. These tests showed that with the small currents used, the transformer secondary currents in all cases were proportional to the currents actually flowing through the area enclosed by the ring. Therefore, subsequent measurements obtained with the ring enclosing the heart gave direct indications of the amount of current flowing through that organ.

## INSERTION OF THE TRANSFORMER

The heart is located in the thorax and is enclosed in a membranous sack called a pericardium; the organ lies free in this sack, its only permanent connection being the great blood vessels at its base. To insert the transformer, the thorax was opened under artificial respiration and the pericardium freed from its attachment to the diaphragm; the transformer then was passed over the apex until it fit snugly about the mid-region of the ventricles where it was held in place by ligatures passing through the pericardium. After the transformer was in place the pericardium was sewed closely to its original attachment on the diaphragm, after which the chest was closed, except for a small opening needed to carry out the transformer secondary leads. By closing the chest after insertion of the transformer and maintaining rhythmic mechanical inflation and deflation of the lungs physiological conditions were preserved as carefully as possible. The transformer secondary leads then were connected to the current measuring apparatus, and the electrodes were applied to various parts of the animal's body. The electrode circuit was arranged so that the current could be adjusted as desired.

## RESULTS

When the current pathway was from the head to the lower extremities, that is, parallel to the axis of the trunk, from 9 to 10 per cent of the current flowing through the body was found to pass through the heart. A slightly greater percentage of the total current was found to flow through the heart when it entered at the right fore-leg than when it entered at the left fore-leg.

In cases where the current entered at one fore-leg and passed out at the other, the experiments showed that only about 3 per cent of the total current passed through the heart. In these tests the current flow was across the body, and accordingly the transformers were attached to the right side of the heart. No current could be detected flowing through the heart when the current path was from hind-leg to hind-leg. Current distribution throughout the animal's body was found to remain substantially constant for a full half hour after death.

Current required to initiate fibrillation in the heart also was studied in several cases using a 5-sec. shock for each test. The amount of current necessary to produce this condition was found to vary considerably among individual animals as would be expected; the maximum, minimum, and average values observed were, respectively, 15, 6, and 9 milliamperes.

In order to check the accuracy of the results found for different current pathways, several tests were made to determine the amount of current that must be applied at the surface of the body to produce fibrillation, without the ring transformers in place.

Results of these experiments confirmed earlier findings; therefore, only one will be mentioned. In this case, a current of 90 milliamperes, entering at the right fore-leg and leaving at the lower extremities of the animal's body, was required to set the heart in fibrillation. With the current flowing between the animal's two fore-legs, 243 milliamperes were required to produce the same condition.

From the results of these experiments it is evident that a much greater proportion of total current flowing through the body will pass through the heart when the current pathway is from either hand to either foot than when it is from hand to hand. The finding that more current flows through the heart when the current path is from the right side to lower extremities than is the case when the current enters the body at the left side, confirms earlier experimental work with rats.

The authors wish to take this opportunity to acknowledge their appreciation to the committee on physiology of the Conference on Electric Shock for providing funds for this work.

# A Review of European Railway Electrification

**The development, present status, and future plans of railway electrification in western Europe were studied by the authors during the spring of 1931 on an inspection tour of the more important systems. General findings and part of the data secured are presented here.**

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DURING the past 30 years in Europe, as in America, heavy electric traction has evolved from short installations on sections of road difficult to operate with steam to the present heavy traffic high speed projects which find justification economically as well as in the increased use of existing facilities. Although as indicated in Table I the United States leads the world in aggregate miles of electrifi- on as it does in total railway mileage, less than 1 nt of the mileage in this country is electrified ent is the corresponding figure for the pean countries. Despite the present s, the electrification of 275 route miles recently and 1,042 route miles are now tion or authorized.

e European countries the standard ic traction as indicated in Table II has been adopted by governmental action; in many of the countries other traction systems also are employed to a minor degree. There are four major traction systems in Europe: the single-phase and three-phase a-c. systems, and the 750/1,500-volt and 3,000-volt d-c. systems. The single-phase a-c. systems (mostly 16.7-cycle, 15-kv.) and the d-c. systems (mostly 1,500-volt) are rapidly expanding; the three-phase (16.7-cycle 3,700-volt) system probably will be slowly extended in the present region. Countries using the a-c. and d-c. systems differ in method of power generation; the d-c. systems purchase or generate power at commercial frequency and are connected with the national power networks, often considered of vital importance in selecting a standard traction system. The a-c. systems (with the exception of Sweden) generate almost all of their power at traction frequency with transmission independent of the industrial network.

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**Castel Madama substation on the industrial-frequency line of the Italian State Railways. Note the three-phase 10-kv. overhead line construction**

## Table I—Mileage and Equipment of European Electrified Railways—End of 1931

| Country | Total Railway Mileage | Electrified Mileage |  |  | Locomotives |  | Cars |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  | Operated |  | Construction |  |  | Passenger |  |  |
|  |  | Route | Track | Route | Total | Electric | Total | Electric | Freight |
| Austria | 4,153 | 510 | 900 | 78 | 2,666 | 168 | 5,840 | 7 | 31,180 |
| France | 27,587 | 1,011 | 2,230 | 100 | 14,643 | 518 | 24,460 | 910 | 391,660 |
| Germany | 36,231 | 968 | 2,373 | 53 | 24,871 | 440 | 65,430 | 2,000[a] | 641,000 |
| Great Britain | 20,300 | 482 | 1,181 | 50 | 22,798 | 33 | 71,020 | 3,058 | 690,220 |
| Italy | 13,560 | 1,392* | 2,500 | 119 | 5,862 | 905[b] | 8,590 | 54 | 152,410 |
| Netherlands | 2,289 | 117 | 293 | ........ | 1,345 | ........ | 5,210 | 307 | 35,120 |
| Spain | 10,138 | 410 | 710 | ........ | ........ | 90 | ........ | 110 | ....... |
| Sweden | 10,367 | 726 | 1,040 | 539 | 1,950 | 246[b] | 4,000 | 4 | 50,000 |
| Switzerland | 3,365 | 1,590* | 3,000 | 103 | 1,356 | 551[b] | 5,320 | 87 | 20,200 |
| Total | 127,990 | 7,206 | 14,227 | 1,042 | ........ | 2,951 | ........ | 6,351 | ....... |
| United States | 250,026 | 2,250 | 5,200 | 200 | 57,174 | 650 | 53,020 | 3,075 | 2,307,000 |

[a] Including 1,500 cars of Berlin suburban service; 800 volt d-c. system.
[b] Including locomotives on order: Italy, 95; Sweden, 104; Switzerland, 33.
* Not including approx. 600 miles of electrified secondary lines in each country.

## Table II—General Means of Traction Energy Supply

| Country | Traction System Adopted | Generation |  |  | Transmission Ownership | Conversion Method* |
|---|---|---|---|---|---|---|
|  |  | Steam or Hydro | Frequency | Ownership |  |  |
| Austria | A.C. 1 ph. 16.7 cy. 15 kv. | Hydro | Traction | Railway | Railway | Transf. |
| France | D.C. 1,500 volts | Hydro | Industrial | Railway | Railway | S.C. & R. |
| Germany | A.C. 1 ph. 16.7 cyc. 15 kv. | Hyd. & St. | Traction | Ry. & Ind. | Ry. & Ind. | Transf. |
| Great Britain | D.C. 750/1,500 volts | Steam | Industrial | Ry. & Ind. | Ry. & Ind. | S.C. & R. |
| Italy | A.C. 3 ph. 3.7 kv., 16.7 cy. | Hydro | Traction | Railway | Railway | Transf. |
| ........ | D.C. 3,000 volts | Hydro | Industrial | Ry. & Ind. | Ry. & Ind. | M.G. & R. |
| Netherlands | D.C. 1,500 volts | Steam | Industrial | Gov. & Ind. | Ry. & Ind. | M.G. & R. |
| Spain | D.C. 1,500 volts | Hydro | Industrial | Industrial | Railway | S.C. |
| Sweden | A.C. 1 ph. 16.7 cy. 16 kv. | Hydro | Trac. & Ind. | Gov. & Ind. | Ry. & Ind. | M.G. |
| Switzerland | A.C. 1 ph. 16.7 cy. 15 kv. | Hydro | Traction | Railway | Railway | Transf. |

* S.C. = Synchronous converters; R. = Rectifiers; M.G. = Motor-generator units; Transf. = Transformers.

Railways using the d-c. traction system are installing mecury arc rectifiers in preference to synchronous converters or motor-generators. Rectifiers are preferred even when regeneration is important, but since it is not feasible at present to construct rectifiers to handle regeneration, this energy is dissipated in resistances. Steep gradients make regeneration attractive, but few of the countries have utilized this form of braking extensively; rheostatic braking is more commonly used, but to a limited degree. In the opinion of many of the railway administrations the form of draft gear (buffer and screw coupler) does not facilitate a locomotive safely braking the train. The installation of automatic couplers, and of air-brakes on freight equipment, is now under discussion; if carried out, automatic air and control circuits will be included in the coupler, differing from the present American type.

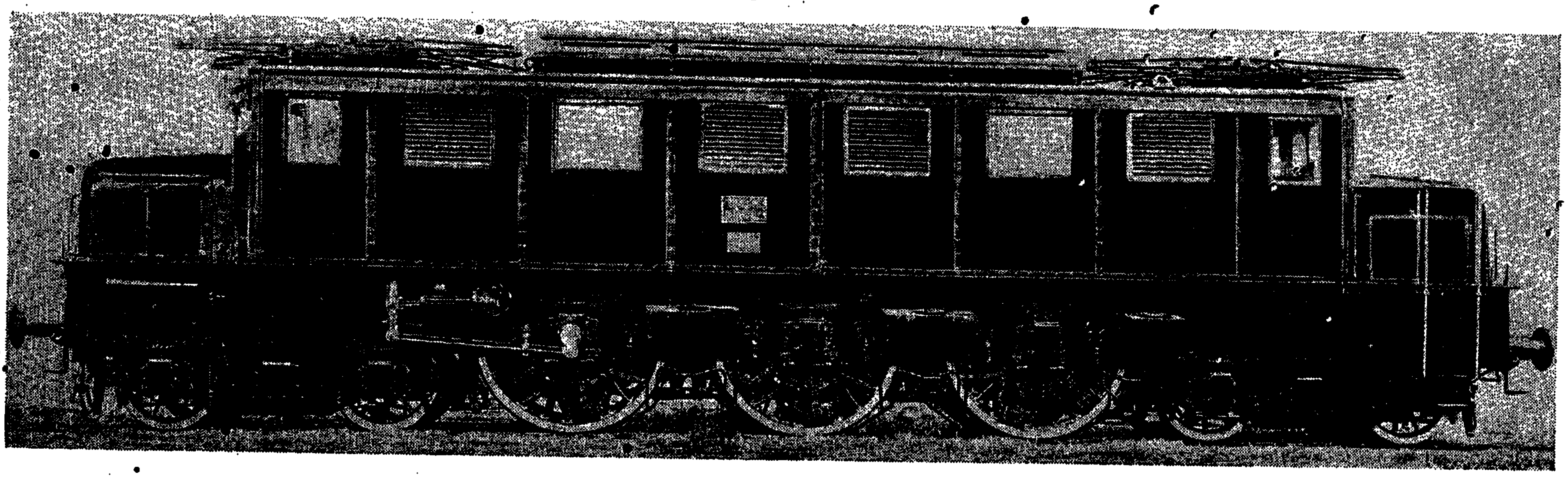
Locomotive construction generally is being standardized so that several manufacturers may supply interchangeable parts built from railway drawings. Similarly the same parts and groups are often adapted for use on various locomotive types. As in the United States, there has recently been a great improvement in the design and construction of the single-phase a-c. commutator motor, and such motors have proved extremely satisfactory. Individual axle drive locomotives generally are built for high speed express and passenger services and the side rod drive for slower services. The intervals between general overhauls vary widely in the different countries and apparently are not greatly influenced by the type of traction system.

## Table III—Contact Wire Heights

|  | Normal Ft.-In. | Minimum Ft.-In. | Maximum Ft.-In. |
|---|---|---|---|
| Austria | — | — | — |
| France | 19—8 | 15— 1 | — |
| Germany | 19—8 | 14— 9 | 21—4 |
| Great Britain | 16—0 | 13—10 | 20—0 |
| Italy | 18—1 | 14— 9 | 19—8 |
| Netherlands | 18—1 | 15— 9 | 18—5 |
| Spain | 18—1 | 13—11 | 20—0 |
| Sweden | 18—5 | 15— 9 | 20—6 |
| Switzerland | 18—1 | 15— 9 | 19—8 |
| United States | — | 15— 2 | 25—0 |

It is a common practise with motor car equipment to place all electrical apparatus, including resistance grids, in a compartment. Cleanliness, accessibility, and protection from damage are the advantages claimed at the expense of using valuable space and the difficulty of securing adequate ventilation. However, as in America, several European railways have placed this apparatus under the car body and have found this arrangement satisfactory. The use of electric train heating has made it necessary to standardize on the type of heaters and jumpers independent of the traction systems, as passenger equipment to a great extent is interchanged. In many of the countries the cars are equipped for both steam and electric heating; when trains include cars without electric heaters, boiler cars are added.

Other noticeable features in Europe are the lower insulation values and the lightness of the catenary contact systems. Contact wire height ranges are given in Table III.



Italian State Railways 3,000-volt d-c., high-speed passenger locomotive, group E-326

### Table IV—Data for French Railways

| Railway | D.C. Voltage | Electrified Mileage |  | No. of Elec. Locomotives | Electric Cars & Trailers |
|---|---|---|---|---|---|
|  |  | Route | Track |  |  |
| State Railway (Paris) | 650 | 51 | 121 | 30 | 445 |
| Paris-Orleans | 1,500 | 148 | 615 | 205 | 240 |
| Midi | 1,500 | 730* | 1,300* | 246 | 45 |
| Paris-Lyons-Medit'n | 1,500 | 82* | 194* | 37 | 180 |
| Total | — | 1,011 | 2,230 | 518 | 910 |

* Approximate.

## FRANCE

Four of the six principal railway systems in France operate electrically about 3.5 per cent of the country's total mileage (see Table IV). The 650-volt third rail Paris suburban lines of the State railway are operated using multiple unit trains with some freight and passenger traffic handled by electric locomotives. At present further extension of the electrification does not appear likely. The Paris-Orleans railway operates electrically south from Paris to Orleans (78 miles) and Vierzon (127 miles); recently a 72-mile extension from Orleans to Tours was authorized. The 1,500-volt d-c. synchronous converter and rectifier substations are supplied from the railway's hydro stations which also exchange power with commercial power systems. Motive power consists of 10 high-speed passenger and 195 medium speed freight and passenger locomotives for freight and through passenger service, and 80 multiple-unit car sets. Suburban trains consist of 1, 2, or 3 three-car 990-hp. multiple-unit sets with control equipment mounted under the car body.

The most extensive electrification is that of the Midi railway, operating in southern France along the rugged country of the Pyrenees, with three lines into Spain. An extensive network of hydro stations and high tension lines interconnected with commercial systems supply power to 1,500-volt d-c. synchronous converter and rectifier substations. Of novel interest is the use of an inclined catenary contact system. Ten high-speed vertical drive locomotives are in service for fast international trains and six locomotives were ordered recently. There are 100 smaller medium-speed passenger and 130 freight locomotives; rheostatic braking is used on all of the freight and half of the passenger locomotives, and regenerative braking on the balance. Forty-five 700-hp. multiple-unit motor cars handle local trains.

The Paris-Lyons-Mediterranean (P.L.M.) system is electrifying a section of its line in southeastern France on one of the main routes to Italy. This installation is interesting for its use of a 1,500-volt third rail, an overhead catenary line being used only at stations. Unusually powerful locomotives are used on the mountain grades.

## SPAIN

The Spanish Northern railway has two important 1,500-volt d-c. electrifications, one in the west between Irun and Alsasua on the Paris-Madrid route and the other in the east between Barcelona and Manresa, Ripoll and Puigcerda, using multiple-unit cars and powerful passenger and freight locomotives, as well as a 3,000-volt d-c. mountain electrification on the Pajares grade in the extreme northwestern region. These lines are wide gage (66 in.). The Vascongados railway between Bilbao and San Sebastian operates an extensive meter gage system at 1,650-volts direct-current, and in western central Spain there is a meter gage 3,000-volt d-c. electrification of a road which handles principally minerals.

The electrical operation of all the trunk lines was reported by a government commission as economically justified, but because of the present financial and political conditions it will probably be some time before this extensive program, covering more than 3,500 route miles, is started.

## ITALY

The lack of coal resources and the abundance of water power in Italy early invited the use of electric traction. After the World War the Italian state railways, as part of their program to improve rail transportation, extended electrification to many trunk lines and adjacent branches. More than 10 per cent of the route mileage, handling about 20 per cent of the total traffic, is now electrically operated. The extent of the four electric traction systems is indicated in Table V. This diversified electric traction experience is of special interest to railway electrification engineers.

Originally adopted as the standard for the country, the three-phase 16.7-cycle 3,700-volt a-c. system in the mountainous northwestern section of the country is now one of the most extensive electrifications in the world. Traction power is purchased or generated at traction frequency and distributed by the railroad's network of low-frequency transmission lines to transformer substations. A satisfactory three-phase overhead contact system, consisting of one or two wires per phase, has been developed although it is complicated and expensive to construct and maintain. The locomotives, through refinements in design and construction, are very reliable in operation and low in maintenance costs. Two speeds, 16 and 32 miles per hr., are obtained on freight; and four speeds, 23, 32, 46, and 64 miles per hr. on passenger locomotives. The principal difficulties with this traction system are the unsatisfactory operation of collectors and contact line at high speeds and the impracticability of closely regulating the speed.

Although the three-phase low-frequency system was satisfactory for the mountain territory, its extension to central and southern Italy was not deemed desirable for it did not satisfy two requirements considered essential in selecting a system for extensive electrification:

1. For level lines a speed of 65 miles per hr. and higher should be reached easily and be capable of slight regulation.
2. To utilize to the best advantage the water power resources of the country, traction power should be of the same frequency as industrial power and where possible existing generating and transmission facilities should be used.

With these requirements in mind the three-phase 45-cycle (industrial frequency) and the 3,000-volt d-c. traction systems were selected in 1919 for trial installations. The three-phase 10-kv. 45-cycle system was installed in 1927–31 on the 107-mile line of 3.1 per cent maximum gradients crossing the Apennines between Rome and Sulmona. Three types of locomotives, also designed for operation on the low frequency system, are in service. Italian railway engineers consider this traction system superior to the low frequency system, as regards generation, transmission and conversion; however, locomotives are heavier, more complicated and expensive, and the contact system more costly to build and maintain. Despite the satisfactory operation it is doubtful if this system will be extended as it fails to meet the first of the above mentioned requirements.

The 3,000-volt d-c. system was installed initially in 1927–28 on the 63-mile line of 2.3 per cent maximum gradients between Foggia and Benevento in southern Italy. Electrical operation was recently extended 60 miles to Naples. Power for this line is purchased entirely from commercial power systems and converted in motor-generator and rectifier substations. A constant tension double contact wire catenary system is installed. For this line a freight and a high-speed passenger locomotive were developed and these two types thoroughly tested in service.

The high voltage d-c. system eventually will be used on the recently completed Naples-Rome direct line and now is being installed on the direct line under construction between Bologna and Florence. The present 82-mile line between Bologna and Florence, the central main route between northern and central Italy, has maximum gradients of 2.6 per cent with numerous tunnels and is a line difficult to operate with steam power. During 1921 to 1927 it was electrified with the three-phase 16.7-cycle system. Construction on the more direct line with lower gradients through the Apennines was started in 1920 involving the longest double-track tunnel (11.5 miles) in the world and reducing the route distance 21 miles. Completion is expected in 1934 and then the present three-phase line will be converted to the 3,000-volt d-c. system.

The extensive use of portable substations for the a-c. and d-c. systems is original and unique. For the 16.7-cycle system a 2,250-kva. three-phase transformer with oil switches is mounted on a special flat car of 100 tons total weight. A 2,000-kw. 3,000-volt rectifier unit is mounted on a partially enclosed car which weighs 82 tons complete with transformer and all switching apparatus. Two such rectifiers have been delivered for test and on new lines it is planned to use such units in place of some of the usual fixed stations.

### Table V—Electrified Sections of Italian State Railways

| Electrification System | Electrically Operated<br>First Year | No. of Locos. | Mileage Route | Mileage Track | Construction Mileage Route | Construction Mileage Track |
|---|---|---|---|---|---|---|
| Three-phase, 16.7 cycle, 3,700 v. | 1906 | 731 | 906 | 1,772 | 59 | 90* |
| Three-phase, 45 cycle, 10 kv. | 1928 | 18 | 108 | 150 | | |
| High voltage D.C. (3,000 v.) | 1927 | 111[a] | 120 | 207 | 60 | 160* |
| Low voltage D.C. (650–800 v.) | 1901 | 28[b] | 114 | 220 | | |
| Total | | 888 | 1,248 | 2,349 | 119 | 250* |

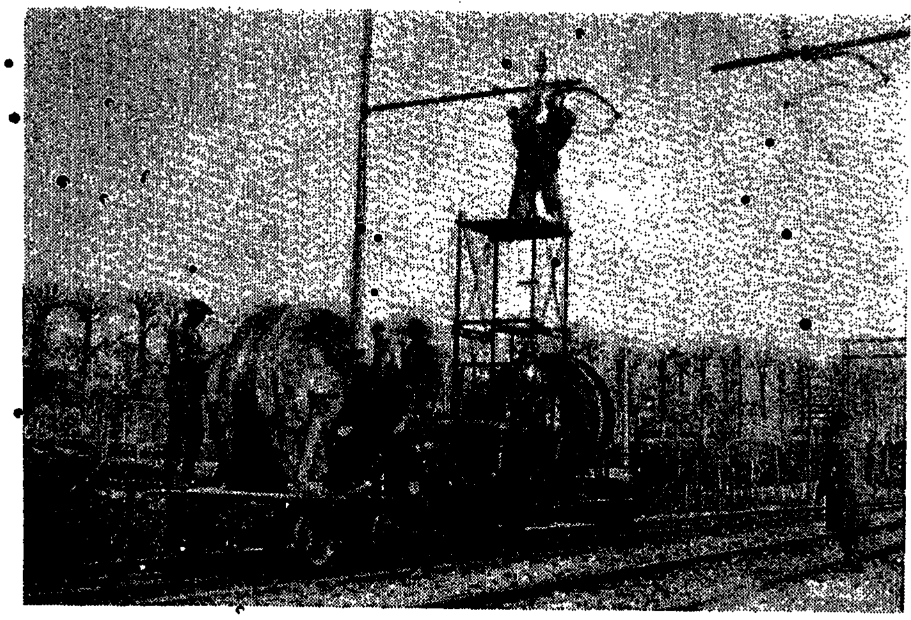
[a] Including locomotives under construction.
[b] Plus 33 motor cars.
* Approximate.

### Table VI—Italian State Railway Three-Phase A-C. Locomotives

| | 16.7 Cycle, 3700 Volt<br>Freight | | F & P | Passenger | | | 45 Cycle, 10 Kv.<br>Frt. | Pass. |
|---|---|---|---|---|---|---|---|---|
| Axle classification | E | E | E | 1C1 | 1D1 | 1D1 | E | 1D1 |
| Group number | E550 | E551 | E554 | E333 | E431 | E432 | E570 | E472 |
| Year built | 1909 | 1924 | 1928 | 1923 | 1924 | 1928 | 1923 | 1923–30 |
| Number built | 186 | 183 | 183 | 40 | 37 | 40 | 4 | 10 |
| Max. speed, m.p.h. | 37 | 37 | 37 | 62 | 62 | 64 | 37.5 | 62 |
| Weight, tons | 70 | 82.5 | 82.5 | 82.5 | 102 | 102 | 77 | 100 |
| Hp.—1 hr. rating | 2,200 | 2,680 | 2,570 | 2,680 | 2,680 | 2,760 | 2,270 | 2,660 |
| No. of motors | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| No. of speeds | 2 | 2 | 2 | 4 | 4 | 4 | 2 | 4 |
| Method of drive | SR—SY | SR—SY | SY—SR | SY—SR | SY—SR | SY—SR | GJS—SR | GJS—SR |

SY—SR Scotch yoke and side rod drive.

GJS—SR Geared jack shaft and side rod drive.



Stringing contact wire on Naples line for Italian State Railways, using 40-hp. gasoline-engine tower-car and small reel-car

Recent a-c. and d-c. locomotives have been carefully standardized. The two types of d-c. locomotives and an 80-ton type B+B branch line freight and passenger locomotive are expected to provide for all future d-c. system requirements. The same motors, contactors, resistances, compressors, gear cases, and axle bearings will be used for these three types.

The privately owned North Milan railway handles a heavy suburban traffic to the Lake District, and 75 track miles over 31 miles of route are electrically operated using the 3,000-volt d-c. system. Power is purchased and converted by rectifiers. Sixteen 720-hp. two-car multiple-unit sets and four electric locotives are in service. Since electrification, local service has been doubled and the running time reduced 35 per cent. Twin contact wires are supported by flexible strand hangers from a copper messenger.

## SWITZERLAND

Switzerland is a country of particular interest because of the early development and present intensive application of electric traction. All the through routes and most of the important local lines have been converted, leaving only secondary lines on which electrification is progressing at the rate of about 60 route miles per year.

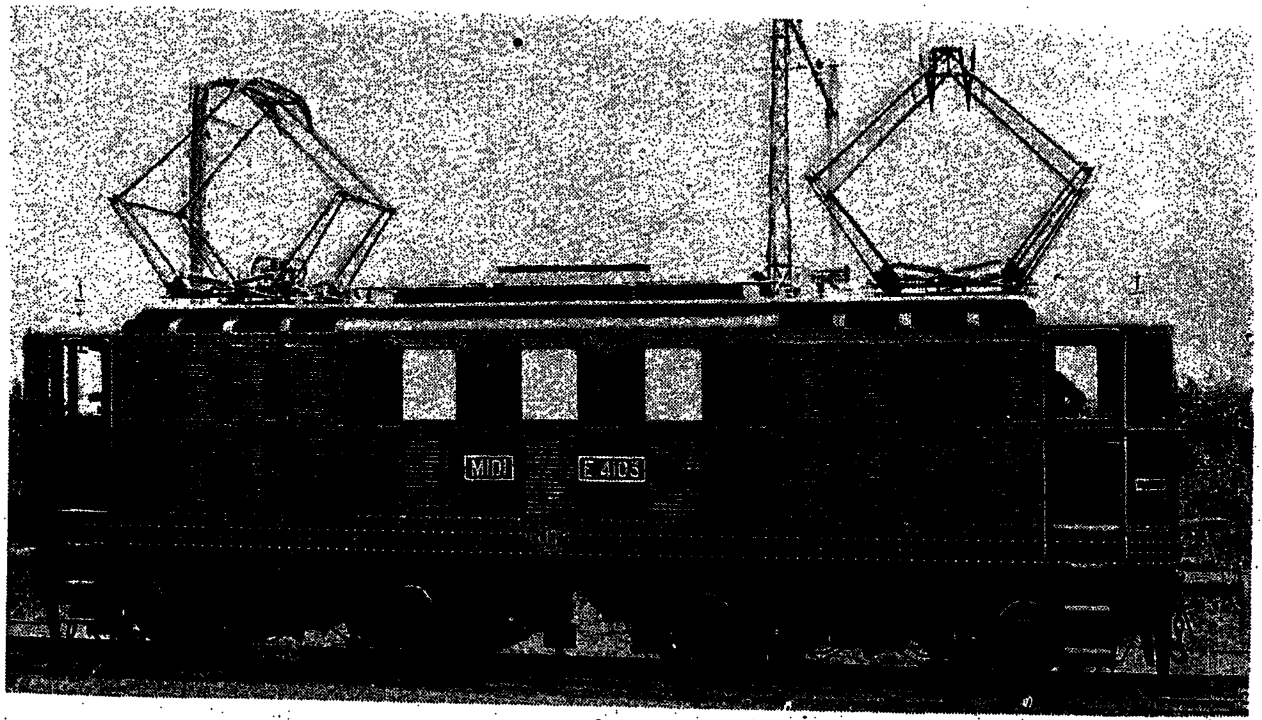
Railway operation is beset by many difficulties; there are steep grades, many tunnels, and much single track mountain line. Coal must be imported and an assured and cheap supply is often difficult to obtain. In almost all sections of the country, however, water power is available in abundance. Electrification, therefore, has been undertaken for economic reasons, for the increased facility in handling heavy through international freight and passenger traffic, and also for national security and the further utilization of natural resources. There are two important standard gage electrified systems—the Federal railways and the Bernese Alps railway; also many electrified narrow gage adhesion and rack lines.

A special commission reported in 1914 that the electrification of certain Federal system routes was desirable economically and the single-phase 16.7-cycle 15-kv. a-c. traction system was recommended, with single-phase traction-frequency generation and transmission by railway owned generating stations and high voltage transmission lines. Plans were being made for the conversion of the St. Gothard line when the World War intervened. In 1923, because of the unemployment situation and coal difficulties, an accelerated program was adopted with approximately a 20 per cent subvention by the government, and phenomenal progress was made during the five years following.

**Table VII—Italian State Railway D-C. Locomotives**

| | 3000 Volt | | 650 V. |
|---|---|---|---|
| | F & P | Pass. | F & P |
| Axle classification | B + B + B | 2C2 | 1 C1 |
| Group number | E 626 | E326 | E321 |
| Year built | 1925–31 | 1931 | 1923 |
| Number built | 91 | 12 | 17 |
| Max. speed, m.p.h. | 56 | 87 | 62 |
| Weight, tons | 98 | 119 | 75 |
| Hp.—1 hr. rating | 2,400 | 2,400 | 1,840 |
| No. of motors | 6 | 6 | 2 |
| No. of speeds | 9 | 9 | |
| Method of drive | Flexible Gear | Flexible Gear | SY–SR |

(SY–SR) Scotch yoke and side rod drive.



ailroad type $B_0$-$B_0$, 1,400-
1,500-volt d-c. elec-
locomotive. Similar
with different gear
ed for much of the
ervice

## Table VIII—Swiss Federal Railway Electric Locomotives

Single phase 16.7-Cycle, 15-Kv. Contact Line

| | F & P | Pass. | Pass. | Pass. | P & F | P & F | Freight |
|---|---|---|---|---|---|---|---|
| Axle classification | 2D1 | 2C1 | 2C1 | 1C1 | 1B + 1B1 | 1B + B1 | 1C + C1 |
| Ry. designation | Ae 4/7 | Ae 3/6 I | Ae 3/6 II | Ae 3/5 | Be 4/7 I | Be 4/6 I | Ce 6/8 I |
| Year built | 1926–31 | 1928 | 1922–26 | 1921–25 | 1921 | 1919–23 | 1920–22 |
| Number built | 125* | 114 | 60 | 26 | 6 | 40 | 33 |
| Max. speed, m.p.h. | 62 | 56 | 56 | 56 | 47 | 47 | 40 |
| Weight, tons | 130 | 105 | 109 | 90 | 122 | 121 | 141 |
| Hp.—1 hr. rating | 2,800 | 2,100 | 2,000 | 1,800 | 2,400 | 2,040 | 2,240 |
| Trac. ef.—1 hr. lbs. | 25,800 | 19,400 | 18,300 | 17,000 | 24,350 | 23,400 | 36,800 |
| Number of motors | 3 | 3 | 2 | 3 | 4 | 4 | 4 |
| Drive | Geared | Geared | GJS–SR | Geared | Geared | GJS—SR | GJS—SR |

* Including 33 locomotives under construction.

GJS—SR Geared jackshaft and side rod drive.

Catenary line and structures on Swiss Federal Railways, showing bracket pull-off pole, 16-kv. insulation and wire screen highway protection

Electric locomotive design has been standardized so that interchangeable equipment is furnished by the three large electrical manufacturers, with another firm making all of the mechanical parts. In recent years the individual axle drive has been preferred for high speed passenger service, 60 per cent of all the locomotives being of this type; the side rod drive is used mainly for the slower services. One-man locomotives are used extensively in freight and local passenger services by the use of the "dead-man" controller. Two new locomotives of about 7,200 hp. recently were completed. All transformer tap changing is done on the high voltage side to avoid handling the large secondary currents with contactors. As on some other locomotives, regeneration is provided only to the extent of the locomotive weight and is intended for use to increase the safe speed when operating light down mountain grades.

The other major electrified system comprises 164 route miles operated by the Bernese Alps railway, which is owned by the Canton of Bern. This line was the first to use the present Swiss standard traction system, installing it for trial in 1910.

### AUSTRIA

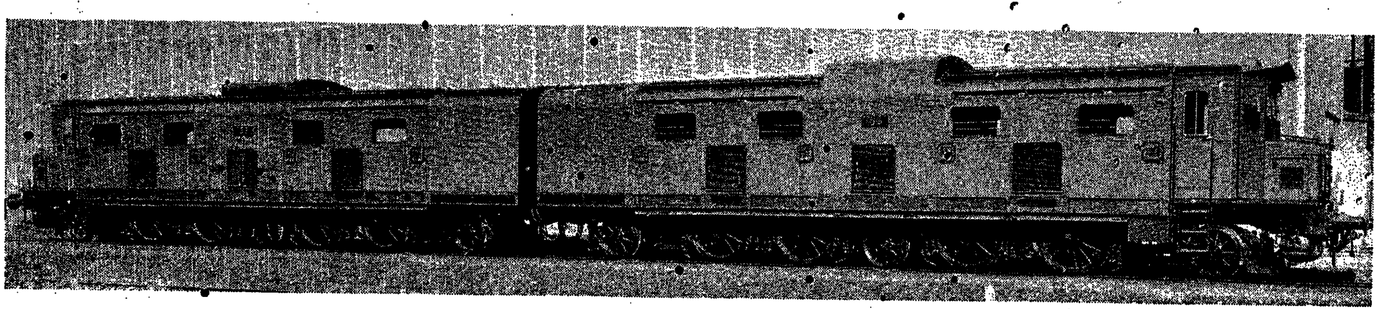
Electric traction was installed on the mountain lines of western Austria for reasons similar to those of Switzerland and to compete with paralleling international routes being electrified in other countries with a reduction in running time which would divert traffic from the Austrian lines. The same traction system (single-phase 16.7-cycle 15-kv.) as used in neighboring Germany and Switzerland was adopted, and, as in these countries, most of the power is generated and transmitted in traction form by railway-owned hydroelectric plants and transmission lines. The locomotives are side rod drive with jackshaft and individual axle drive with geared horizontal and bevel-geared vertical motors. Because of the financial conditions and the present low price of coal the further electrification of some 500 route miles has been postponed.

### GERMANY

The extensive use of electric traction in Germany began after the World War. There are four important and several smaller electrified sections of the German State railways located in widely scattered parts of the country. Three of these districts, the Bavarian, Silesian and the Central, use the single-phase 16.7-cycle, 15-kv. a-c. system adopted as the standard for trunk lines, and the Berlin district an 800-volt d-c. third-rail system for a rapid-transit suburban service. Single-phase, 15-cycle, 15-kv. power is used on a 30-route-mile electrification at Basle and 25-cycle, 6-kv. power on the 23-mile Hamburg installation.

In the Bavarian district through freight and passenger trains and heavy suburban traffic from Munich are handled electrically over a total of about 1,000 track miles on 434 miles of route, which gradually is being extended. Most of the power is purchased, using special traction-system generators and transmission lines. A total of 190 passenger, freight, and switching locomotives and 37 motor-car sets are assigned to this section. Most of the freight and some of the passenger locomotives are the side rod drive type with geared jackshaft; high-speed passenger locomotives are type 2D1 or 1D1 individual axle drive. Multiple-unit car trains consist of one or two units, each consisting of a two-motored 750-hp. steel car and three trailers. Both the air-cooled transformer and the oil circuit breaker are in a special compartment. The locomotives and motor cars have "dead-man" control for one-man operation.

The mountain road electrification between Breslau



New St. Gothard line 7,200-hp.-$1B_01\ B_01 + 1B_01B_01$ locomotive for Swiss Federal Railways, prior to installing electrical equipment

and Gorlitz in the Silesian district includes about 217 route miles and 507 track miles. Power is generated by the railway at traction frequency, utilizing a very low grade of coal. The Central district (Leipzig-Halle-Magdeburg) has a heavy traffic which is handled at high speeds over fairly level country, using locomotives and motor cars on about 118 electrified route miles and 409 track miles. Power is generated in traction form, using a peat that cannot be burned in locomotive boilers.

The Berlin suburban lines were electrified in 1924 to furnish a rapid transit service on 145 miles of route (365 miles of track) using multiple-unit car equipment. Purchased power is converted by synchronous converters and rectifiers; the rectifier installation is the largest in the world for a single system. Contrary to common practise the anode and rectifier tank are at ground potential and the third rail is negative.

A meter gage, 12-mile 1,650-volt, d-c. railway, the Zugspitze, was recently completed to the highest mountain peak in Germany, using an adhesion, rack and aerial line. Glass-tube rectifiers convert three-phase 50-cycle power for traction purposes.

German locomotive design and construction also are standardized. Air blast transformers are used and now the electrical manufacturers are perfecting an air blast circuit breaker so that no oil will be required on the locomotive or motor car.

## SWEDEN

Sweden is rich in water power resources, but entirely lacking in coal deposits, hence careful consideration has been given to the advantages of electric traction. The State railway system, operating most of the trunk lines and about 40 per cent of the total mileage, now has more than 14 per cent of the route mileage and 25 per cent of the traffic electrically operated. A very extensive program of electrification extension is under way and scheduled for completion in 1934.

One of the first electric installations (1912–1922) is the Northern Ore line. This 287-mile line, which goes 170 miles north of the Arctic Circle 's therefore the most northerly electrified rail- in the world; handles heavy ore traffic from on mines at Gellivare and Kiruna east to Lulea e Gulf of Bothnia and west to Narvik in Norway he Atlantic Ocean. The 15-cycle 15-kv. single- e a-c. traction system, with high voltage single-phase transmission to track-side substations from a central mixed-frequency hydroelectric plant, was adopted.

Four-car multiple unit suburban train at Munich. There is one motor car with three trailers

After the war electrical operation was considered for the Stockholm to Gothenburg trunk line and the government again studied the matter of a traction system, concluding that the single-phase 16.7-cycle, 16-kv. a-c. system would be satisfactory. Careful study of the location of a negative return wire on the catenary structure and the use of booster transformers for minimum communication circuit interference satisfied the government communications board, which cabled their circuits or removed them from the railroad right-of-way. Traction power was obtained from the existing commercial power stations and transmission networks by installing frequency-converter substations about 58 miles apart without paralleling traction-frequency feeder or transmission lines.

A geared jackshaft side rod drive type 1C1 locomotive, identical for both freight and passenger services except in gear ratio, was adopted as standard. These locomotives handle a 550-ton passenger train or 990-ton freight train over the profile of 1 per cent maximum gradients. Sweden is now the only important country that has not at least partially adopted the individual axle drive, and is the only country extensively using a wooden locomotive cab.

In 1931 electrification of the 392-mile trunk line south from Stockholm to the ferry terminals at Malmo and Tralleborg, and three branches totaling 177 miles which connect this line with the Gothenburg electrification, was authorized at an estimated gross cost of about $17,000,000. Complete electrical operation is to be started in 1934. Commercial power will be purchased from existing power systems without the construction of additional high tension lines, and six motor-generator frequency-converter substations having an average spacing of 70 miles will supply power to the contact line. As the branch lines do not require additional substations there is an average of 90 route miles per substation. Seventy-five standard freight and passenger locomotives, 21 switching and 8 battery-trolley locomotives have been ordered and are now under construction for this electrification.

A comparison of estimated operating costs shows a very favorable annual saving above all fixed charges with electric operation. The eventual electrification of about 600 route miles of other trunk lines is contemplated, which will then complete the electrification of the government system's main routes.

At Sundsvall a privately owned railway is completing a 12-mile electrification using the 1,500-volt d-c. system and 8 motor-car and trailer sets. Many of the smaller privately owned short railways throughout the country have adopted with great success diesel-electric cars on branch lines of light traffic.

### DENMARK

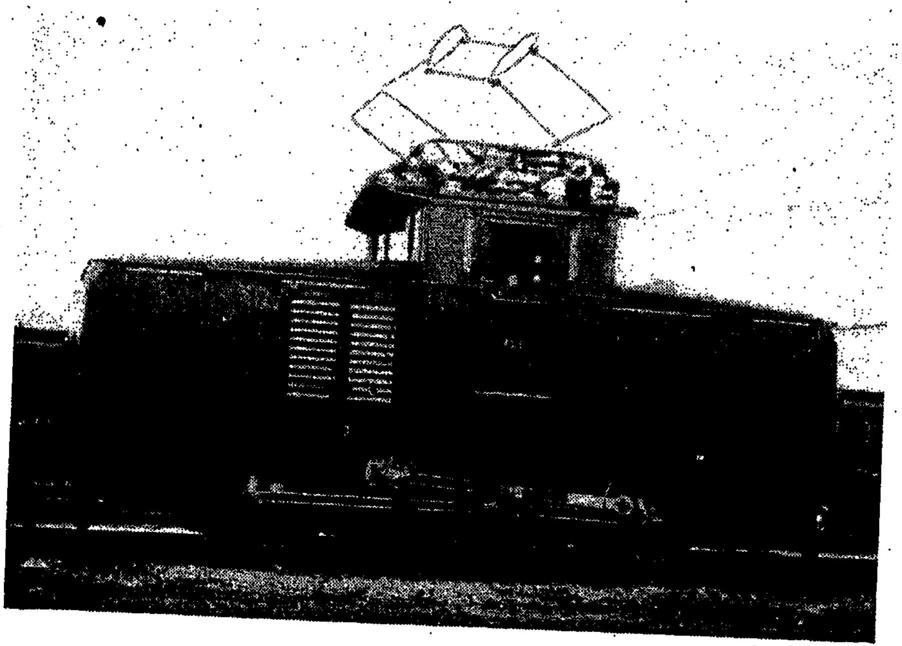
The Danish state railways have under consideration the electrification of the heavier traffic suburban lines in the vicinity of Copenhagen, to increase the capacity of the present congested trackage through that city, and to effect economies in operation. Electrical operation of about 23 miles of route using multiple-unit equipment is contemplated, and a d-c. overhead contact system at 1,500 or 3,000 volts was studied.

Gasoline-engine passenger cars, some direct drive and others electric drive, and diesel-electric locomotives are used extensively on branch lines and on the main routes. Two type 2D2 900-hp. diesel-electric locomotives were recently delivered to the railway; these locomotives are designed to handle a 275-ton train at 46 miles per hr. and have an operating range of 370 miles, thereby enabling the longest round trip to be made without refueling.

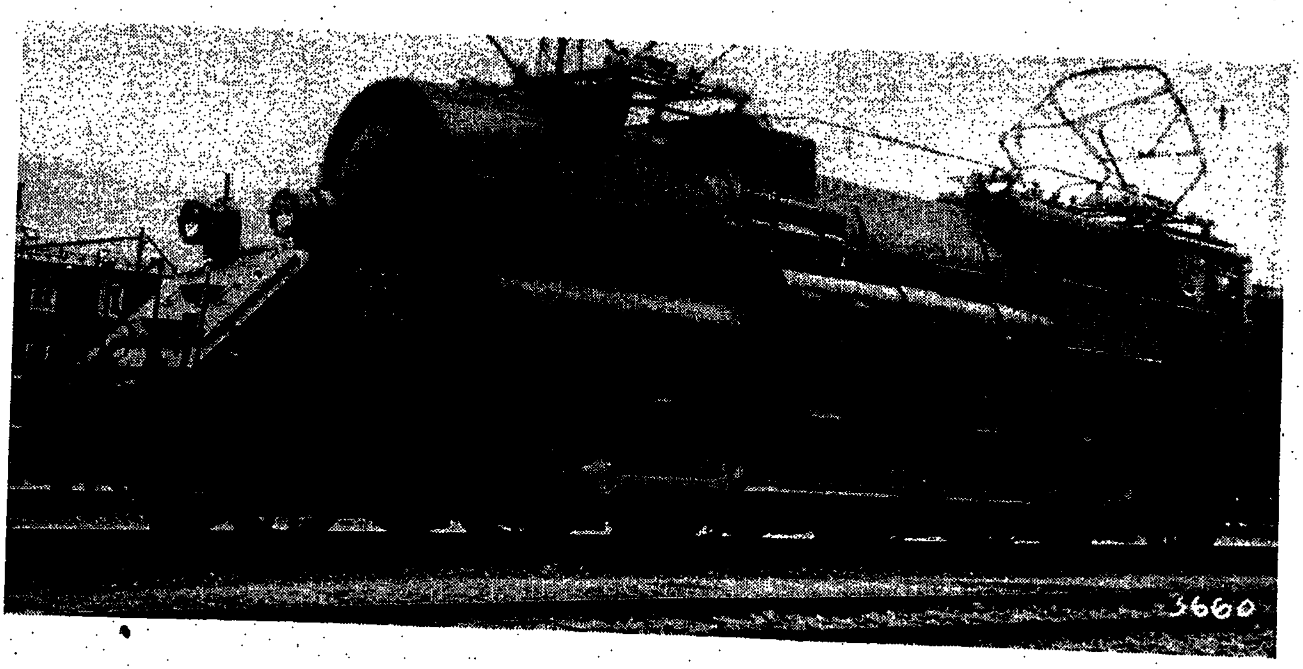
### THE NETHERLANDS

Approximately three-quarters of the country's railway mileage is operated by the Netherlands railway, which has about 7 per cent of its route now under electrical operation for passenger service, using multiple-unit cars. In May 1931, the lines from Amsterdam to Uitgeest and Alkmaar, and Velsen to Uitgeest were converted to electrical operation, in addition to the Amsterdam-The Hague-Rotterdam line and branches which have been electrically operated since 1927. Purchased power is used entirely, and converted to 1,500-volts direct current by automatic rectifier substations which are supervisory controlled from adjacent interlocking towers. The one motor-generator substation is manually operated. On the earlier installation multi-unit substations were spaced 6.9 to 10.2 miles apart with intermediate sectionalizing tie stations. The recent installation consists of single-unit substations spaced about 4 miles apart. The contact system is of the twin contact wire type, and is unique for the suspension of both contact wires from the same hanger.

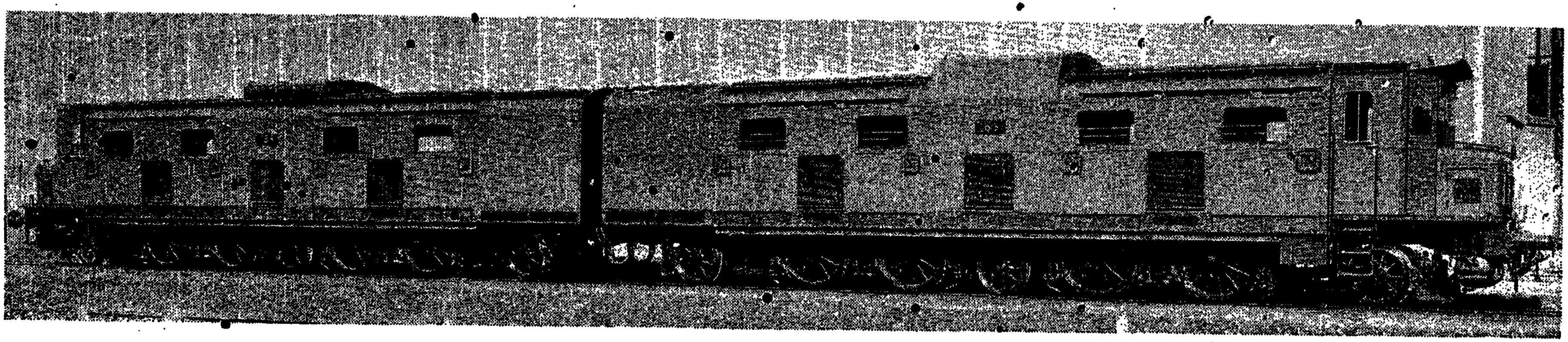
Rolling stock of the most modern type is used, and eight different 760-hp. motor or trailer cars of various passenger classes are combined as desired to make up trains of from 2 to 10 cars. The latest motor cars have roller-axle and motor armature bearings. As the railway faces severe competition from motor buses, other heavy traffic passenger lines, as from Amsterdam to Utrecht, probably will be electrified. The



**(Above) New Swedish type $U_b$ switching locomotive equipped with four control positions in a high center cab**



**(Right) Unique type of motor-generator freight locomotive constructed in 1930 for Austrian State Railways. It operates on a single-phase $16^{2}/_{3}$-cycle 15-kv. contact line and is equipped for full train weight regeneration**



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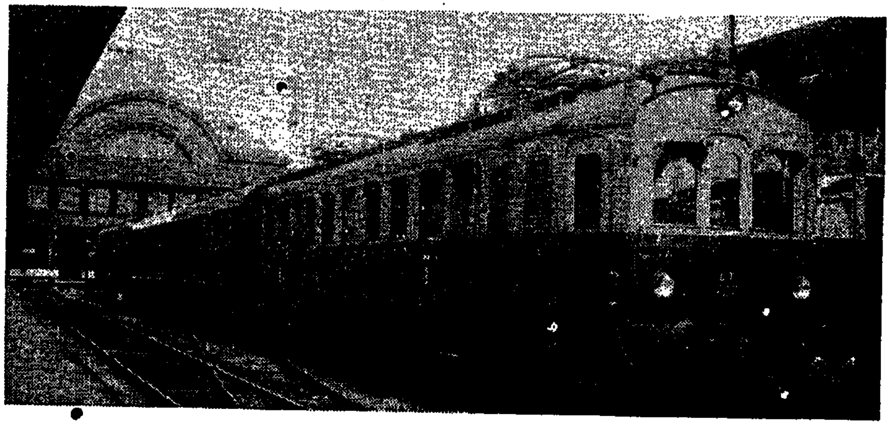

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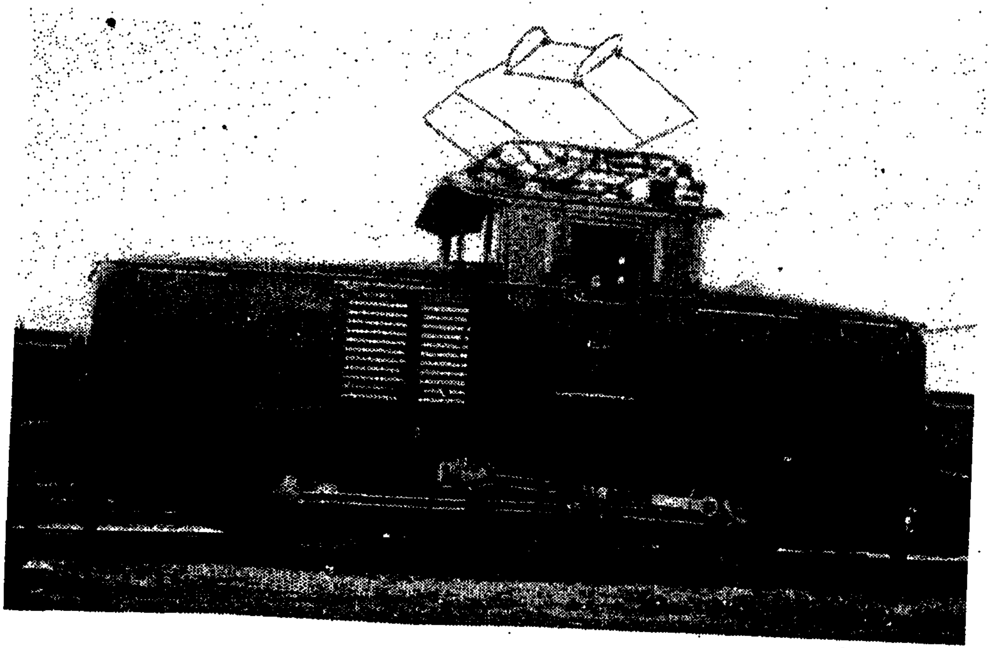
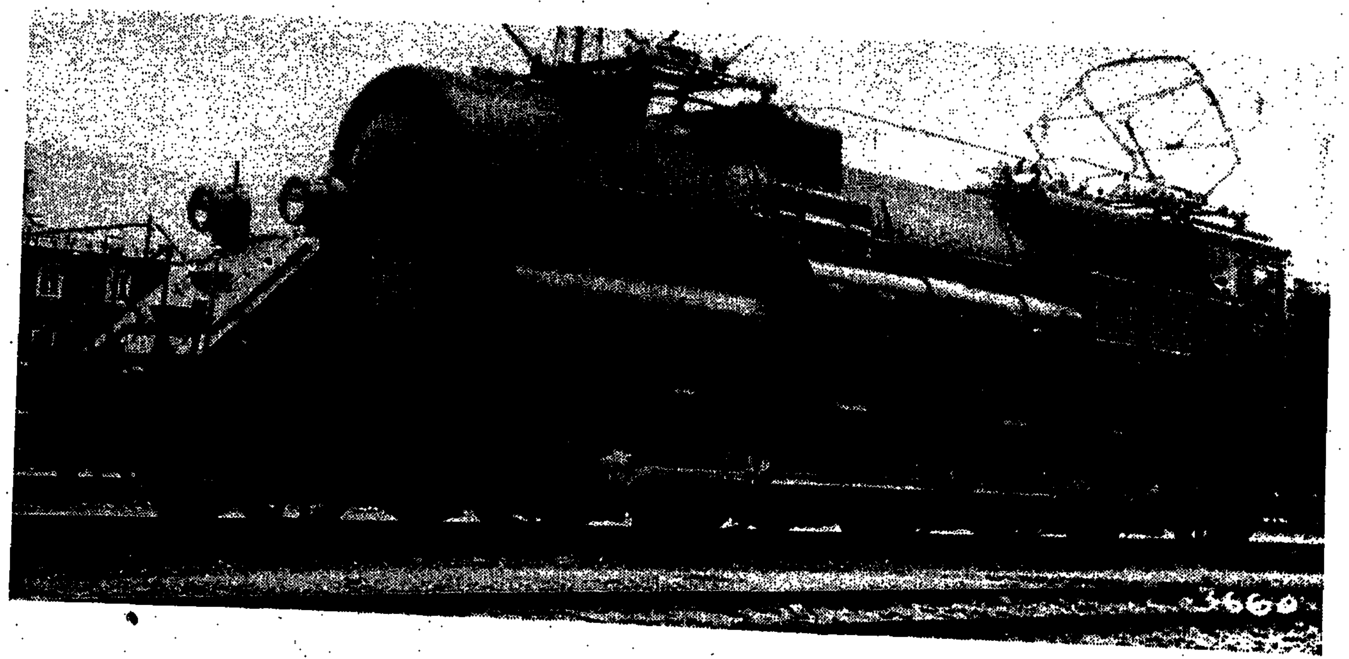


**(Above) New Swedish type $U_b$ switching locomotive equipped with four control positions in a high center cab**



**(Right) Unique type of motor-generator freight locomotive constructed in 1930 for Austrian State Railways. It operates on a single-phase $16^{2}/_{3}$-cycle 15-kv. contact line and is equipped for full train weight regeneration**

electrical operation of freight and through international passenger trains is not planned at present.

## GREAT BRITAIN

The three outstanding recent electric traction developments are:

1. The Ministry of Transport report on main line railway electrification (1931) commonly referred to as the "Weir Report."
2. Extension of the Southern Railway's third-rail electrification to Brighton on the Channel coast.
3. Inauguration of electric service between Manchester and Altrincham using 1,500-volt d-c. multiple-unit equipment.

With the exception of the Newport-Shildon 1,500-volt d-c. line all of the electrification is suburban and much of the mileage is in the London district; other installations are located at Manchester, Liverpool, Lancaster, Newcastle-on-Tyne, and Newport. During the past decade, with the formation of the national grid system for electric power transmission and distribution, the government has viewed with increasing interest the possibility of using electric traction on the railroads and various committees have reported on this subject. The Pringle (1927) report definitely recommended the use of direct-current, either 750-volt third-rail or 1,500-volt overhead, with the possibility of considering 3,000 volts for special conditions. The Weir report (March 1931) recommended that if the railroads are to be electrified practically all of the lines must be converted to avoid the uneconomical conditions incidental to dual steam and electric operation. This stupendous project, covering almost 20,000 route miles, would be spread over a period of 20 years, the total gross expenditure being estimated at $1,964,000,000.

The Southern Railway's London suburban electrification, the largest of its kind in the world, has 300 route and 800 track miles electrically operated. With the completion of the Brighton electrification at the end of 1932 the electric system will include 965 track miles on 350 miles of route; this is about 18 per cent of the company's mileage. The 650-volt d-c. third-rail distribution system is supplied by 52 synchronous converter substations converting from 25 cycles. Eighteen supervisory-controlled single-unit rectifier substations are to supply power for the Brighton extension from the 50-cycle national grid sytem. Multiple-unit equipment is used entirely, in trains of from 2 to 9 cars. The standard motor unit consists of two 550-hp. motor cars and an intermediate trailer; a few two-car motor units were purchased recently. Two-car trailer units are used between motor units. All control apparatus including resistance grids is placed in a compartment of the motor car. There are a total of 1,948 cars of which 832 are motorized; most of these have been converted from former steam equipment.

The Manchester, South Junction, and Altrincham railway is the first electrification to follow the 1927 committee's recommendation of 1,500-volt direct current. Electric service with multiple-unit equipment was inaugurated in May 1931. The line is 8.7 miles long (28 track miles) and was electrified to meet bus competition more effectively. Purchased power is converted by synchronous converters and a rectifier. The catenary contact system consists of a copper messenger, stranded auxiliary, and a 318,000 cir. mil contact wire, totaling 1,000,000 cir. mils in conductivity. Three-car units consisting of a motor car, trailer, and control trailer are used; trains may be made up of 1, 2, or 3 such units. Motor cars, weighing 63 tons, have four 330-hp. motors and a maximum safe speed of 70 miles per hr.; trailer cars weigh 35 tons.

European railways are apparently well satisfied that the operating economies, increased speed, cleanliness, increased track capacity, and use of natural resources such as water power or low grades of coal, are advantages that justify further extension of railway electrification even during a severe economic crisis. The execution of such projects during times of depression has been of material assistance in alleviating unemployment in several of the countries. Perhaps America could profitably follow such an example.

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# Impulse Testing of Large Transformers

**Impulse voltage tests provide valuable information concerning a transformer's ability to withstand high voltage surges in service. By making such tests with the transformers excited, power current will flow into any faults which occur, thus providing unmistakable evidence regarding the nature and location of such faults.**

By
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PRESENT standard dielectric tests at low frequency no longer are considered to give a satisfactory measure of the real strength of transformer insulation. This fact was emphasized during the recent A.I.E.E. winter convention, at which the question of impulse testing of large power transformers received considerable attention. In general, engineers who discussed the question at that time agree that impulse tests would afford valuable information concerning the ability of transformers to withstand surges encountered in service, and that steps should be taken to establish a standard test pro-

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Prepared especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

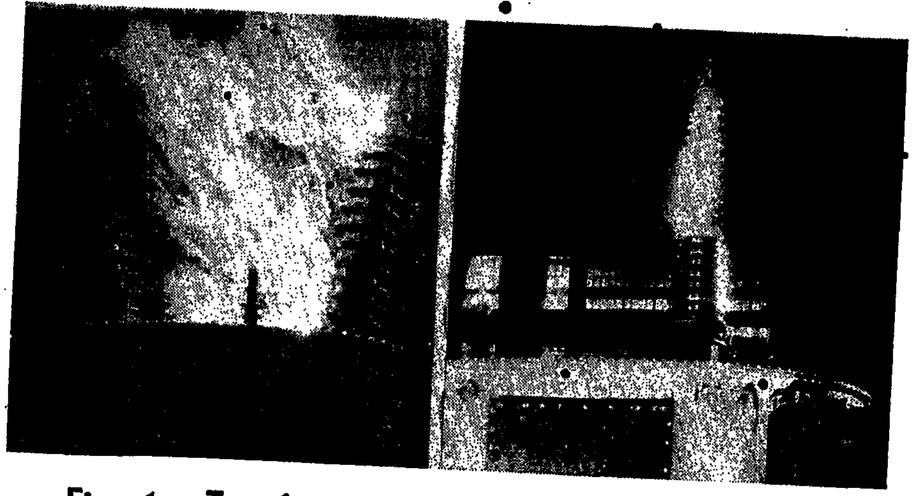


**Fig. 1. Transformer bushing flashovers (left) with superposed surge and normal-frequency voltages; (right) with surge voltage only applied**

cedure for impulse testing. It was suggested further that the A.I.E.E. electrical machinery committee might undertake this task.

Development of a suitable method of impulse testing for transformers involves several problems if such methods can be considered safe and reliable measures of insulation strength. One of the principal difficulties encountered is the detection of insulation failures when they occur, and some question exists as to whether a method less thorough than complete disassembly of the transformer insulation is adequate for this purpose. The problem of detecting insulation failure is solved, however, by the simultaneous application of surge voltage and normal frequency exciting voltage, so that failure is accompanied by the flow of power current.

When an insulation failure occurs during a normal-frequency dielectric test, the fact that failure has occurred is demonstrated by the obvious effects of the power current that flows into the fault. In the surge test as ordinarily made, the energy discharged by the surge generator may be insufficient to produce unquestionable physical effects, if the failure occurs within the transformer winding. If on the other hand the surge be applied with the transformer excited, as in normal service, an insulation failure caused by the surge voltage would be followed by power current; the fact of such failure would be as patent and as unmistakable as in the case of a failure in service, or of a failure during a normal-frequency dielectric test. (See Fig. 1.)

Simultaneous application of surge and power voltages has been recognized generally as the satisfactory solution of this problem, and this combination test was carried out successfully on distribution transformers two years ago. In applying the method to high voltage transformers, however, additional difficulties are encountered in obtaining a simple and practical method of preventing the transformer voltage from injuring the surge testing equipment. This latter problem has been solved by F. J. Vogel of the Westinghouse company by an ingenious application of the Torok tube, an arc rupturing device operating on the deion principle.

In Fig. 2 is shown a circuit developed for testing high voltage transformers by the method just outlined and employing a deion gap as mentioned. In this diagram, the surge generator is tripped by gaps *3* and *4*, and these in turn by the voltage from the condenser $C_t$. If a positive surge is required from the generator, a negative voltage is required from $C_t$. Gap *3* is set so that the voltage of $C_1$ is not quite sufficient to cause breakdown; gap *4* is set at a lower voltage than gap *3*. A small negative voltage from the tripping condenser trips gaps *3* and *4* in succession, gaps *1* and *2* insuring the synchronizing of the surge with the 60-cycle voltage. Voltage at gap *1* is a maximum when voltage from the tripping transformer is at maximum positive polarity at the crest of the wave. Gap *2* is set high enough only to with-

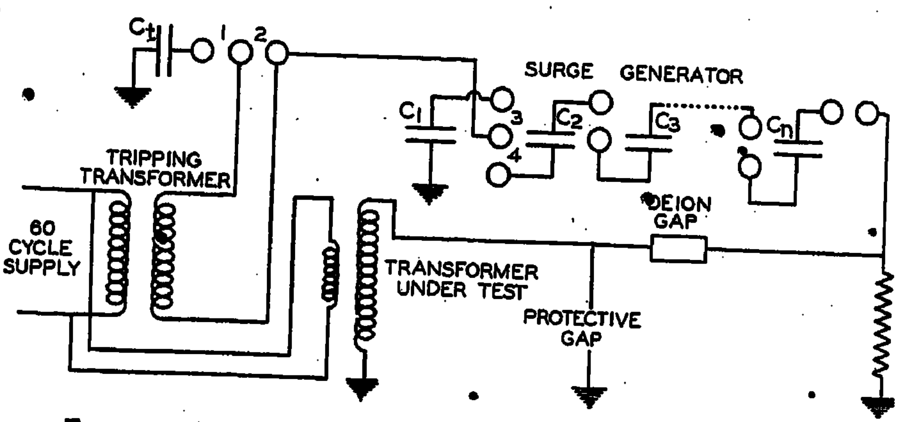
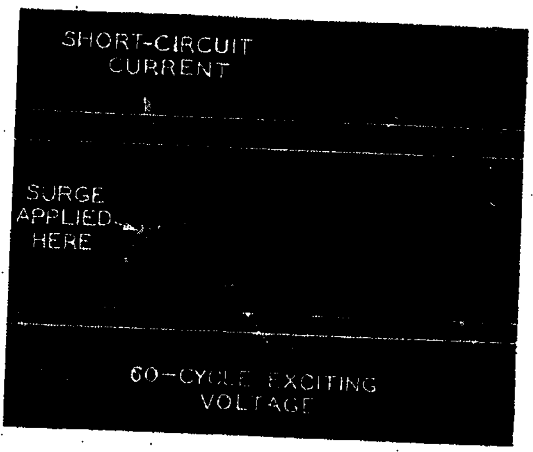


**Fig. 2. Equipment for testing transformers with surges applied at crest of exciting voltage wave**

Application of this method to high voltage transformers was made possible by use of the deion gap to protect the surge generator from the transformer voltage

**Fig. 3. Oscillogram of transformer bushing flashover showing application of surge and beginning of short-circuit current at crest of exciting voltage wave**



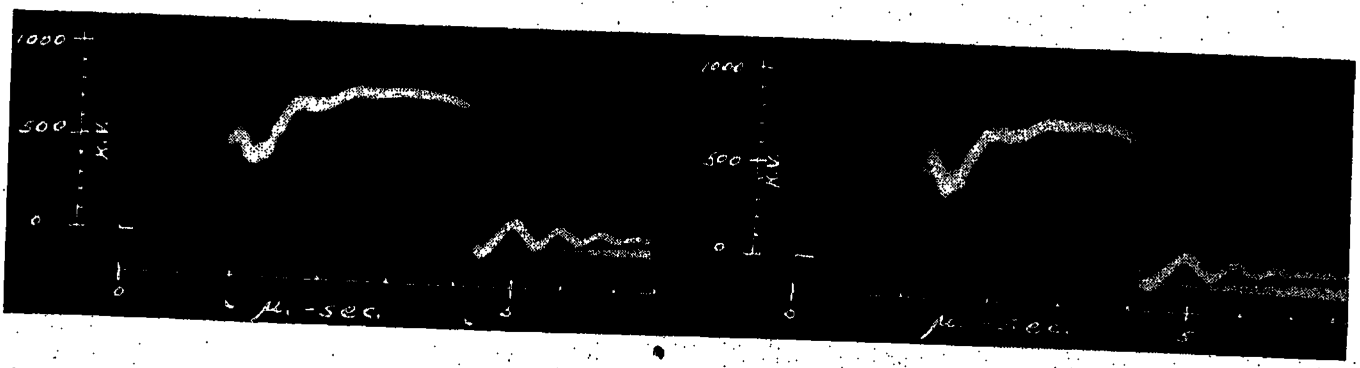


**Fig. 4. Addition of deion gap to circuit does not affect surge voltage; (left) surge voltage wave with gap; (right) without gap.**

For this test, oscillograph was connected between surge generator and deion gap stand the 60-cycle voltage. If gap *1* is set so that it will just break down when the 60-cycle voltage is applied, the crest of the wave will be picked off automatically.

Operation of the circuit described is illustrated by Fig. 3, which shows an oscillogram taken during a bushing flashover on a 138-kv. transformer. Application of the surge and the start of the short circuit are indicated clearly. Timing of the surge is arranged so that it is imposed at the crest of the 60-cycle voltage wave. Experience has shown that with the surge and power voltages synchronized in this manner, power current will follow in every case in which the transformer insulation fails to withstand the surge voltage. It should be noted further that the use of the deion gap as shown in Fig. 2 does not affect the surge voltage. This is demonstrated by Fig. 4, which shows oscillograms of surge voltage during bushing flashovers with and without such a gap in the circuit. It may be noted that the voltage and time-lag of the flashovers are practically the same in both cases.

This development is particularly timely considering the discussion on the subject at the recent A.I.E.E. winter convention mentioned in the beginning of this article. Availability of this test procedure opens up the possibility of an entirely new basis for establishing the sufficiency of transformer insulation. Furthermore, it brings within the range of practical discussion the project of standardizing the test procedure, test wave, and voltage values for surge testing.

# Design Features of Potentiometers

**Fully nine-tenths of all potentiometers now being built are said to find their way into industrial plants. Low-resistance instruments are shown to possess many advantages over those with high resistance.**

By
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POGGENDORF'S "compensation" circuit, from which all potentiometer circuits have been developed, was brought out about the middle of the nineteenth century. This original circuit was devised for measuring the open circuit e.m.f. of primary cells; in all precise potentiometers of today, the open circuit voltage of a primary cell is used for standardizing the potentiometer current. As practically all of the primary cells used with potentiometers develop an open circuit e.m.f. a little in excess of 1 volt, most potentiometers have been designed to have ranges of approximately 1.5 or 2.0 volts. An important exception arises in the case of potentiometers designed for precise measurements of temperature with thermocouples. Such instruments usually are designed to have a range of approximately 0.1 or 0.01 volt.

Potentiometers have been designed with a range as high as 15 or 16 volts, but usually such a high range is not required. It is preferable not to connect high voltage directly to the potentiometer, but to extend the range of a 1.5- or 2-volt potentiometer to any desired value by means of a voltage divider, commonly known as a "volt-box." It is usual practise to equip potentiometers with range-changing devices, so that two or three ranges are available in one instrument.

## POTENTIOMETER RESISTANCE

No direct relationship exists between the potentiometer range and its resistance. It is true that all low range potentiometers for use with thermocouples are designed to have low resistance, as a high resistance in the potentiometer circuit would interfere with obtaining the desired sensitivity; but it does not follow that a high range instrument should have a high resistance. While a high resistance may be used in a high range potentiometer, a low-resistance potentiometer is preferable for the following reasons:

1. Inherently, a low-resistance potentiometer makes possible a higher sensitivity than can be obtained with a high-resistance instrument.
2. Errors due to current leakage between the potentiometer parts are much smaller in a low-resistance instrument.
3. Low-resistance coils are more stable than high-resistance coils.
4. Proper galvanometer damping is easy to obtain with a low-resistance potentiometer and difficult to obtain with a high-resistance instrument.
5. In a low-resistance potentiometer at least one-tenth of the range may be covered with a slide wire; this results in a simple and inexpensive construction.
6. For the same sensitivity, a low-resistance potentiometer permits using a higher resistance in the volt-box.

Distinct advantages result from the use of low resistance even in a high range potentiometer where the high-resistance instrument is not barred out definitely because of lack of sensitivity. For in-

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Based upon "Design of Potentiometers" (No. 31-118) presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

stance in measuring current by measuring the potential drop across a current shunt, if shunts of equal energy dissipating capacity are used, the low-resistance potentiometer permits the use of a more simple and rugged form of galvanometer; if galvanometers of the same sensitivity are used, then the energy dissipating capacity, and consequently the size and cost of the current shunt, may be reduced when working with the low-resistance potentiometer.

Lower operating current represents the only advantage which may be claimed for the high-resistance potentiometer; this advantage, however, can be shown to be more apparent than real. In the days when a 50- or 60- ampere-hour storage cell was a fairly expensive item and when it was necessary to reset all of the potentiometer dials in order to check the potentiometer current against the standard cell, a potentiometer requiring much less current than 0.01 or 0.02 ampere probably had a real advantage. Now that fairly large storage cells are available at small cost and potentiometers are designed so that the current may be checked instantly without resetting the dials, an instrument requiring as much as 0.01 or 0.02 ampere is at no disadvantage, but on the contrary is at an advantage because with the higher current any small leakage currents produce much smaller errors. In Fig. 1 is shown the extremely small drift in current for a typical potentiometer requiring 0.02 ampere supplied from a storage cell of 60-ampere-hour capacity.

Reference already has been made to the possibility of using a slide wire for the lower part of the range of a low-resistance potentiometer. As a matter of fact, however, it is not at all essential and almost all of the low-resistance potentiometers designed for making precise temperature measurements with thermocouples are equipped with dial switches throughout.

A low-range, low-resistance, dial-type potentiometer recently proposed is shown schematically in Fig. 2. This instrument has a low total resistance (less than 15 ohms and substantially constant) and the circuit arrangement is such that errors due to resistance variation and parasitic e.m.f.'s at the switch contacts are reduced to less than one step on the fifth dial.

While the instrument shown in Fig. 2 has six dials, not more than five are intended to be used at one time, as the use of all six would assume a higher accuracy in the standard cell and in the resistance adjustments than is obtainable in ordinary practise. The sixth dial is included as the equivalent of a range-changing device, that is, when using dials I to V inclusive, the range is approximately 0.1 volt; when using dials II to VI inclusive, it is about 0.01 volt.

## DEFLECTION POTENTIOMETERS

In the deflection potentiometer, the principal part of the potential being measured is balanced against a known potential just as is done in an ordinary null potentiometer; the remaining small portion of the unknown potential is read from the deflection of a calibrated galvanometer. The fundamental requirement in the design of a deflection potentiometer is that, for all connections and adjustments of the instrument, there must be no appreciable change in the galvanometer circuit resistance.

Aside from its use in photometric measurements, the most important application of the deflection potentiometer is in checking large numbers of portable indicating instruments. In discussing this latter problem, Dr. H. B. Brooks, of the United States Bureau of Standards, points out that null potentiometers are the most accurate for the purpose, but require too much time to use. Doctor Brooks further shows that long scale laboratory standard deflecting instruments, while faster in operation, are not sufficiently accurate for the purpose. He concludes that "the need unquestionably exists for a type of instrument for current and voltage measurements which will have properties intermediate between those of the ordinary deflection instrument and the elaborate potentiometer."

It is interesting to note that although the deflection potentiometer does provide an instrument intermediate in accuracy between the null potentiometer and the laboratory standard deflection instruments, it is not intermediate in speed of operation. It is faster than either of the other two. In the deflection potentiometer, the galvanometer pointer is short and light and this results in a short period. Furthermore, it is unnecessary to take the time to estimate tenths of a division. Because the position of the pointer does not change very much and need not be observed more closely than to one

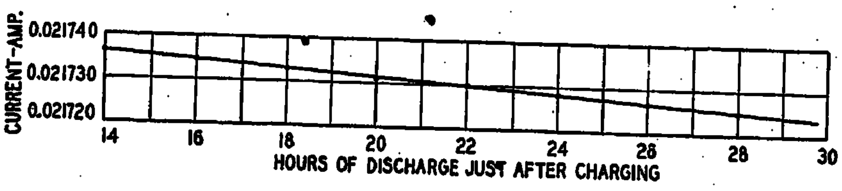

**Fig. 1. Current drift for a typical 100-ohm potentiometer supplied from a lead storage cell**

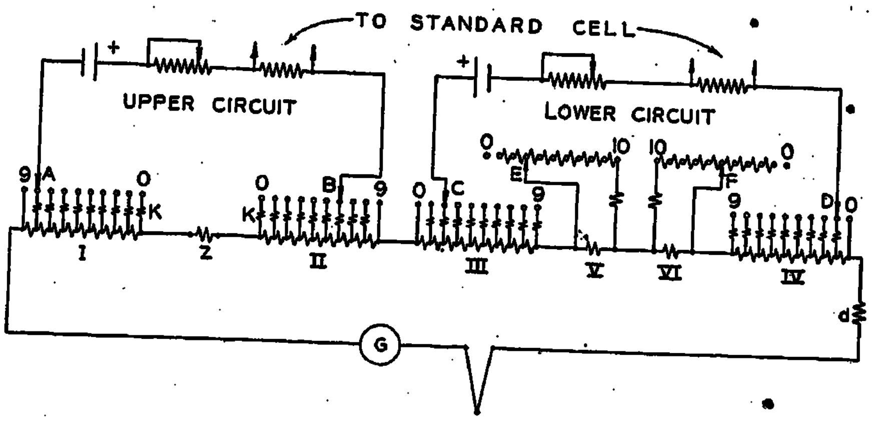

**Fig. 2. Schematic diagram of a recently proposed low-resistance potentiometer with two ranges (0.1 and 0.01 volt, respectively) and five dials**

This instrument is especially adapted for thermocouple measurements. Upper and lower circuits are connected so as to utilize the difference of the two potentials, thus avoiding the necessity of reducing both potentials to zero to obtain a zero reading on the potentiometer division, it is unnecessary for the operator to change his position frequently in order to remain in line with the pointer. This latter precaution is essential in reading laboratory standard deflection instruments to avoid parallax errors.

In conclusion it may be of interest to point out that the use of potentiometers in industrial plants has increased remarkably in recent years. A fair estimate indicates that nine-tenths of the potentiometers put into use each year go into industrial plant applications and only one-tenth into laboratory service. This is not due to any falling off in the laboratory uses of potentiometers, but rather to the rapid increase in industrial plant uses of the instrument, in the form of portable indicating potentiometers and automatic recorders and controllers.

# Tie Line Load Control

**Regulation of tie lines interconnecting two electric power systems is a problem of load control rather than one involving principally system frequency; for best results, the control equipment must be automatic. Apparatus developed to meet this need is described in this article, and the results from two years' operating experience are outlined.**

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PARALLEL or interconnected operation of several power systems has brought to the fore a new and most important problem; namely, that of controlling the interchange of power between the several systems. This problem first came into prominence under the name of frequency control and many engineers attacked it from that point of view. As a matter of fact the problem is one of load control instead, and as yet little has been done toward its solution. The division of power in a loop under the control of phase shifting equipment is a related problem, but should not be confused with the control of total interchange by the prime mover governors. Attempts to regulate two or more interconnected systems with an automatic frequency regulator on each system promptly will develop the fact that the load variations on the systems will be so dissimilar that power flow over the tie lines cannot be regulated in this manner. In fact it has been observed in some cases that when the bulk of the load change falls upon one system, the power flow over the tie line exceeds the load change by the amount required to accelerate or retard the systems.

Recognizing the problem as one of load rather than frequency control, the Duquesne Light Company several years ago enlisted the coöperation of several equipment manufacturers in a series of load control experiments. The tests were made on the 36,000-kva. 132-kv. tie between the Colfax station of the Duquesne Company, and the Springdale station of the West Penn Power Company. As a result of this and continued investigation, automatic load control

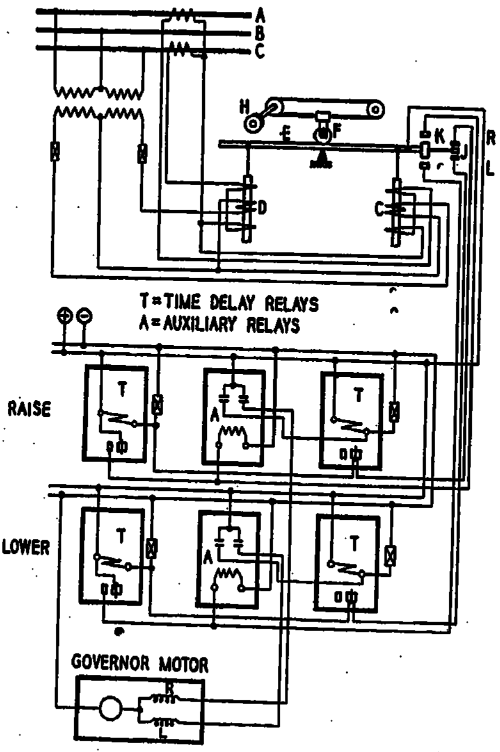

**Fig. 1. Westinghouse solenoidtype automatic load regulator for interconnecting tie lines**

With weight F immediately above the fulcrum, arm E is balanced and requires zero watts in coils C and D to maintain balance. Any power flow through the coils will cause the arm to raise or lower depending upon the direction of flow. For small changes in load contact J engages either the "raise" or "lower" stationary contacts R or L. These contacts send an impulse to the governor motor through time delay relays approximately $2^1/_2$ sec. after the contacts have closed. If the period of contact engagement is less than $2^1/_2$ sec. no correction results. A second set of time delay relays is provided to limit the length of impulse delivered to the governors to a predetermined value. To take care of large load changes, a second set of contacts K is provided to operate the speed changer motor directly through auxiliary relays without time delay. Contacts K are set to close for approximately 10,000 kw. change in load, but hunting of the regulator in this zone is prevented by the opening of these contacts at 5,000 kw. Below this value the auxiliary contacts J to return the line load gradually to normal.

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Based upon "Tie-Line Control of Interconnected Networks" (No. 31-127) presented at the A.I.E.E. Pacific Coast convention, Lake Tahoe, Calif., August 25-28, 1931.

over the tie line and automatic control of the generator output in accordance with a predetermined program, both being supervised by or subservient to automatic frequency control, have been in successful operation at the Colfax station for some time. While many improvements no doubt are yet to be made, operation of existing equipment exceeds expectations extant at the time the investigational work was started some two years ago.

The maximum economy possible as a result of interconnection will not be obtained unless the most efficient loadings of the several generating units on the interconnected system are adhered to closely. This loading must be anticipated and must take account not only of the inherent efficiency of the generating station and units, but numerous other factors. Since maximum economy cannot be obtained with manual control, for the most advantageous operation the control must be automatic. Such control must be simple, reliable, accurate, and easy to set for any desired division of load between generating units.

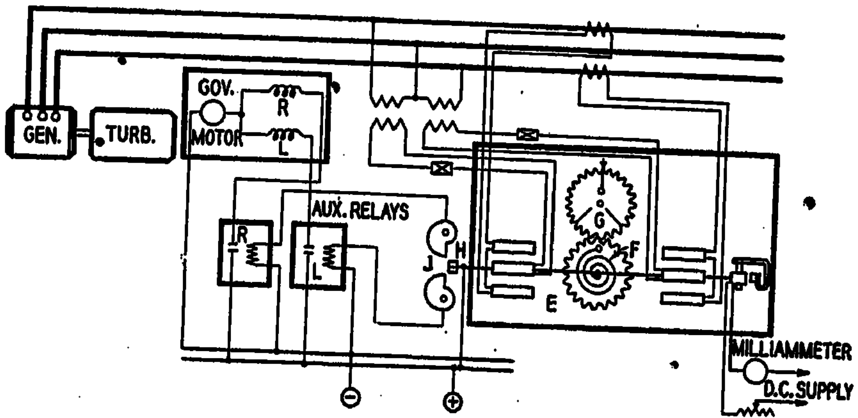


**Fig. 2. Westinghouse Kelvin-balance type automatic tie-line load regulator**

A calibrated spring F attached to a geared disk allows the torque due to the power in the Kelvin balance to be neutralized by rotating the disk G to the right or left; a balance thus can be made at any load within the limits of the spring F. Variations in load cause the balance to deflect contact H which in turn makes contact with the motor-driven rotating cams J thereby routing "raise" and "lower" impulses to the governor motor. As the unbalance decreases the period of contact engagement with the cams decreases and the duration of impulses to the governor motor also decreases thus providing an anti-hunting feature. Disk G can be rotated by a position transmitter, or a D'Arsonval element may be attached to the lever E to counteract the torque in the balance, making the device readily adapted to remote control

Performance of a tie line connecting two large power systems involves the rate of load change, and the inertia and sensitivity of the prime mover governors, as well as the electrical characteristics of the line. A load change on one system causes a redistribution of the load between the various prime movers, and also a transient distribution which occurs during the period of adjustment to the new load. This transient condition is not noticeable in a closely tied system such as the average metropolitan utility. However, if there is only one tie line connecting two systems, these load transients are concentrated and assume considerable importance. The chief requirements of a successful tie-line load regulator therefore are that it must not respond to these small *transient* load changes, but it must respond to small *sustained* changes. However, when large load changes occur the regulator must respond whether such fluctuations are temporary or sustained.

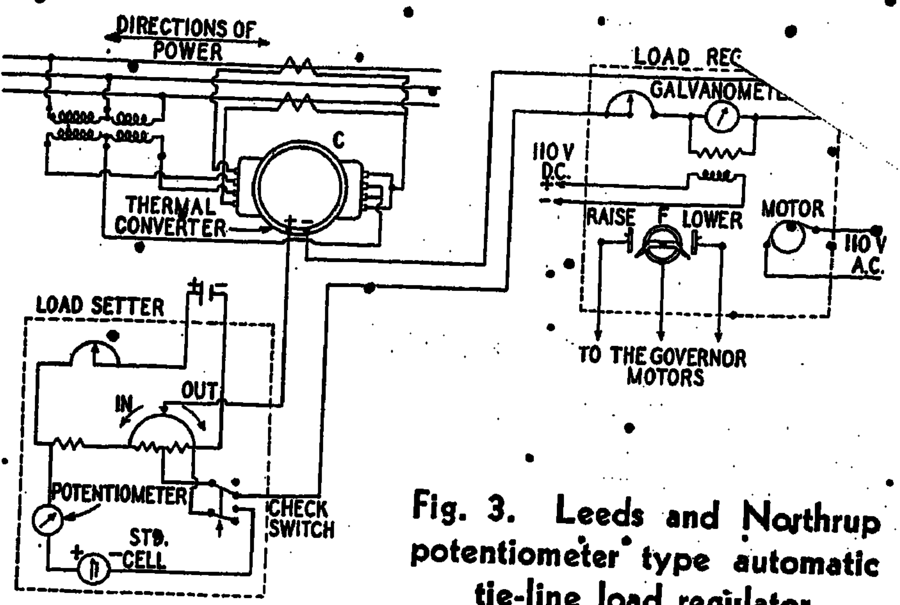


**Fig. 3. Leeds and Northrup potentiometer type automatic tie-line load regulator**

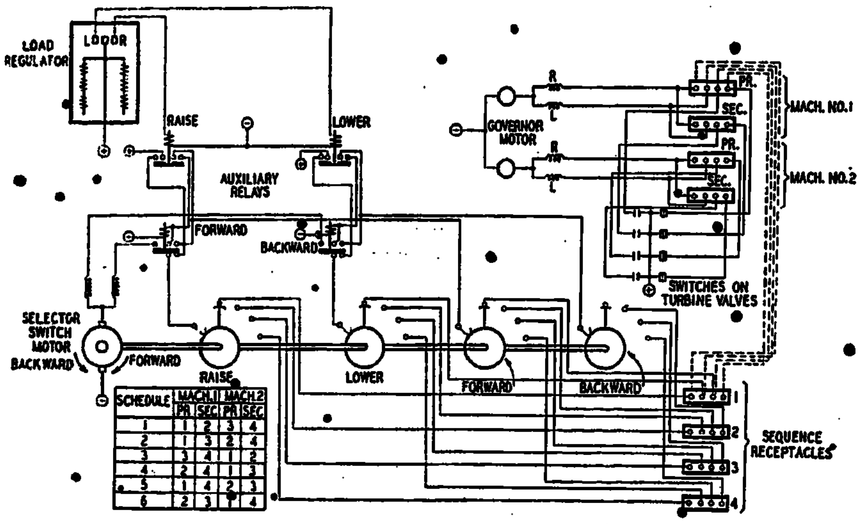
The load setter is a potentiometer with a calibrated dial, and is adjusted to give a potential equal to the thermocouple potential of the thermal converter for a given tie-line load. These two potentials are connected in opposition through a sensitive galvanometer. This galvanometer deflects in proportion to the difference in potential between the load setter and the thermocouples of the thermal converter. Any unbalance indicated by the galvanometer is checked by the rotating cam mechanism F, which delivers corrective impulses to the turbine governor in proportion to the load errors.

## TIE-LINE LOAD REGULATORS

Three types of tie-line load regulators are shown in Figs. 1 to 3. The first type (Fig. 1) was devised primarily to eliminate corrective action due to transient changes, but to respond rapidly to load changes of reasonable magnitude. It consists essentially of two solenoids connected to two phases of the tie line, and arranged to assist each other in balancing an arm which carries two sets of control contacts on its outer end. Time delay relays prevent the regulator from responding to small transient changes. This device has shown considerable promise, in that it does not cause corrections to be made which must be counteracted immediately by those of a reverse order.

A large change of turbine loading to counteract load in a tie line results in considerable energy being supplied to the system to accelerate it while changing the phase angle relation across the tie line. It can be seen that after the phase angle is changed this energy still is available to supply load, which results in an overshooting of the proper value. It is essential that any regulator responding at a rapid rate must have a wide zone about the final position in which the load corrections are made in small increments.

This first regulator is not well adapted to remote control, and for applications involving this feature, another design utilizing the Kelvin balance (Fig. 2) has been developed. No time delay relays are used with this device; it will cause more corrective impulses to be delivered to the governor motors than the device first described, although it is somewhat slower in correcting large errors due to rapid changes of load. Under average conditions, however, it will maintain a closer integrated load.



| SCHEDULE | MACH. 1 | | MACH. 2 | |
|---|---|---|---|---|
| | PR | SEC | PR | SEC |
| 1 | 1 | 2 | 3 | 4 |
| 2 | 1 | 3 | 2 | 4 |
| 3 | 3 | 4 | 1 | 2 |
| 4 | 2 | 4 | 1 | 3 |
| 5 | 1 | 4 | 2 | 3 |
| 6 | 2 | 3 | 1 | 4 |

Fig. 4. Automatic program load controller for use with tie-line load regulators

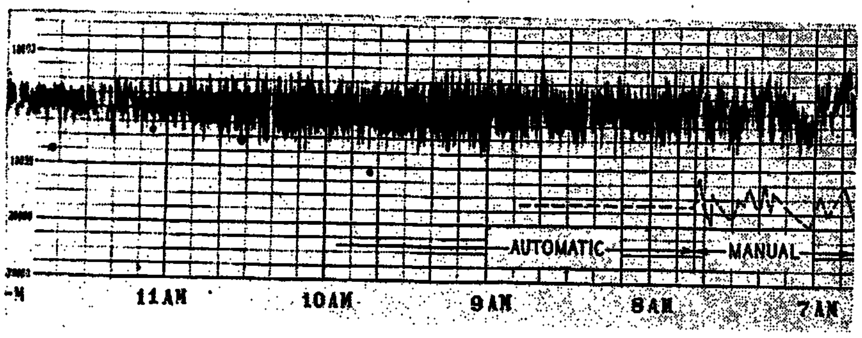


Fig. 5. Comparison between manual and automatic control. Broken line shows average of load swings

The solution of the problem of tie-line control offered by the Leeds and Northrup Company consists essentially of a master element comprising a thermal converter and a load setter as shown in Fig. 3. The thermal converter is similar to the Lincoln thermal demand meter except that instead of using a bi-metal strip to indicate the kilowatt load, thermocouples are inserted which produce a potential for transmission to suitable receiving apparatus. This device tends to change the turbine loads until the tie-line load flowing through the thermal converter sets up a potential equal to that of the load setter. This control gives very satisfactory operation.

## Program Load Control

In the past where frequency control has been adopted, common practise has been to confine the regulating to one station and usually to one generating unit. When the regulating device controlled more than one unit, the division of load between units sometimes was found to be erratic; therefore load balancing schemes were devised to enable the various units to carry their proper share of load increments.

These devices are relatively simple and perform satisfactorily, but the principle of dividing all load increments proportionately between units in a steam station does not necessarily make for maximum efficiency. Most operators have considered the output of the machine and have not taken into account the inefficiency due to operating with steam control valves in a throttling position. In the equipment developed to meet the requirements established by the Duquesne company operators, load scheduling is based upon turbine valve positions rather than upon generator output. Thus each turbine is maintained at its most efficient valve opening regardless of the effect of the many variables entering into the position of the valve with reference to the load.

In Fig. 4 may be seen a schematic diagram of equipment used to obtain automatic division of load in accordance with the predetermined program loading at the Colfax station. Six generating units are installed in this station, two of them of 60,000-kw. capacity each; two of 41,250 kw. each; and two of 30,000 kw. each. On the larger steam turbines the nozzles are arranged usually in three groups, each fed from the primary, secondary, and tertiary valves, respectively. These valves are equipped with auxiliary switches to establish the proper sequence of loading. Referring to Fig. 4, the motor-operated selector switch routes the "raise" or "lower" impulses from the tie-line load regulator through the load scheduling device to the turbine governors. In order to simplify the description and diagram as much as possible only two machines have been shown, each with one primary and one secondary valve.

Six loading schedules are shown in the table (Fig. 4); to set up any one of these schedules, a system of receptacles and plugs is used, four machine receptacles and four sequence receptacles being required for the case illustrated. The selector switch has four independent contact arms, two of which are used for routing the "raise" or "lower" impulses and two for controlling the selector switch driving motor. The position of the selector switch is determined by the position of the valve auxiliary switches and also by the way in which the machine and sequence receptacles are connected by jumpers. For example consider that machine No. 1 primary receptacle is connected to sequence receptacle No. 1, No. 1 secondary to sequence 2, No. 2 primary to sequence 3, and No. 2 secondary to sequence 4 receptacles. The operation then would be as follows with both machines carrying minimum load and the selector switch in position 1: on increasing the load, an impulse from the regulator is routed through to No. 1 governor motor.

After the load has increased to the point where the primary valve is wide open, the auxiliary switch on this valve makes contact energizing the forward control of the selector switch driving motor on the next raising impulse. The selector switch rotates in the forward direction until cut off by the forward contact breaking the circuit with the first contact. The width of the forward and backward contacts are such that the motor will drift to the next position after the control circuit is broken. The switch now is in position 2 and the raising or lowering impulses are still routed to No. 1 governor motor. In the same manner, the selector switch transfers to the next position after the secondary valve on machine No. 1 opens fully. With decreasing load the selector switch returns, the motor being energized through the "backward" selector switch arm and the valve switch contacts which are closed when the valves are closed. The forward and backward auxiliary relays seal in so that the selector switch travels at least one position and also breaks the control circuit from the regulator so that control is broken during the transfer.

## OPERATING EXPERIENCES

The instantaneous speed of any system is a function of the system load and of the setting of the turbine governors; hence, with any given setting the speed of the system will vary as the load changes. If two systems are interconnected through one or more lines, the speed of the entire interconnection becomes a function of all the governors and of the total load; the generator load does not bear a direct relation to the demand on that particular system, but since it is a function of system speed, the excess demand must be supplied through the interconnecting tie lines.

If the two systems under control are of the same size and have approximately the same load characteristics, it is possible for them to remain in parallel for reasonable periods of time when operating on straight speed-governor control without overloading the tie lines. In such interconnections, it is customary for the system controlling the tie line to adjust its governors to maintain 60-cycle frequency if this correction will tend to correct the tie-line loading. With frequency control on one system, all of the load changes occurring on the entire interconnection obviously will appear eventually on the units under automatic control, so that all the net load changes of the system without frequency control will appear in the tie line.

Observation on the Colfax-Springdale tie line for a period of two years has shown the foregoing reasoning to be correct. It is generally assumed that tie-line load control tends to make frequency control more difficult to obtain. This is based upon the assumption that all load changes on one system must flow over the tie line and be compensated for by the frequency-control equipment before the tie-line equipment has functioned. That is to say, the load change is corrected first by the frequency regulator and later by the tie-line control, which in turn requires that the frequency regulator drop an amount of load equal to that picked up by the tie-line load control. This reasoning would be sound if the frequency-control equipment were much faster in response than the tie-line regulator. As a matter of fact, experience has shown that the two types of control work together satisfactorily although possibly at the expense of increased frequency of operation during some periods.

It has been observed also that the use of tie-line regulators affects the permissible neutral zone of the frequency regulators on the interconnected systems. The initial installation of tie-line load control at Colfax was made at a time when the West Penn company was maintaining its system frequency to within ±0.05 cycle by means of automatic frequency control devices at its Windsor station. Later, in order to reduce the overloading of other tie lines, the frequency was allowed to vary as much as ±0.15 cycle. This resulted in a more erratic power flow over the tie line and an increase in corrective operation of the tie-line regulator. It is felt that while the solution to tie-line load swings may be put off temporarily by allowing frequency to drift, eventually system speeds will have to be held rigidly at 60 cycles and load control adopted on all tie lines to permit maximum utilization of existing transmission facilities between the interconnected systems.

Another interesting observation has been the effect on the normal band of power swings with manual and with automatic control, respectively. This comparison is shown in Fig. 10. Under manual control the average load drifts without any appreciable change in the width of the band of power swings; whereas with automatic control the average load is maintained very close to the desired amount, but the band of power swings is enlarged greatly.

In October 1930 tests were conducted by the Duquesne and West Penn companies to determine the rate of response of the tie-line control and of the frequency control to rapid load changes. This was accomplished by rapidly lowering the load on the Colfax station 30,000 kw. and allowing the load and frequency controllers at the Colfax and Windsor stations, respectively, to correct the load distribution and frequency without manual assistance. In order to analyze the instantaneous load shifts which ensued, high speed test meters were used; the results of two typical tests are shown in Fig. 6. In both tests, when 30,000 kw. was dropped at Colfax the power flow over the tie line increased almost simultaneously and at the same rate as the load was dropped. This initial division is a characteristic of interconnected systems when the load change occurs at the end of the tie line opposite from the point of frequency control. Without tie-line control the Windsor station being under frequency control would have picked up the entire 30,000 kw. dropped. However, the curves show that in both cases the tie-line load control had accomplished considerable correction by operating on Colfax unit No. 1 before the frequency regulator at Windsor had caused that station to acquire much of the load dropped.

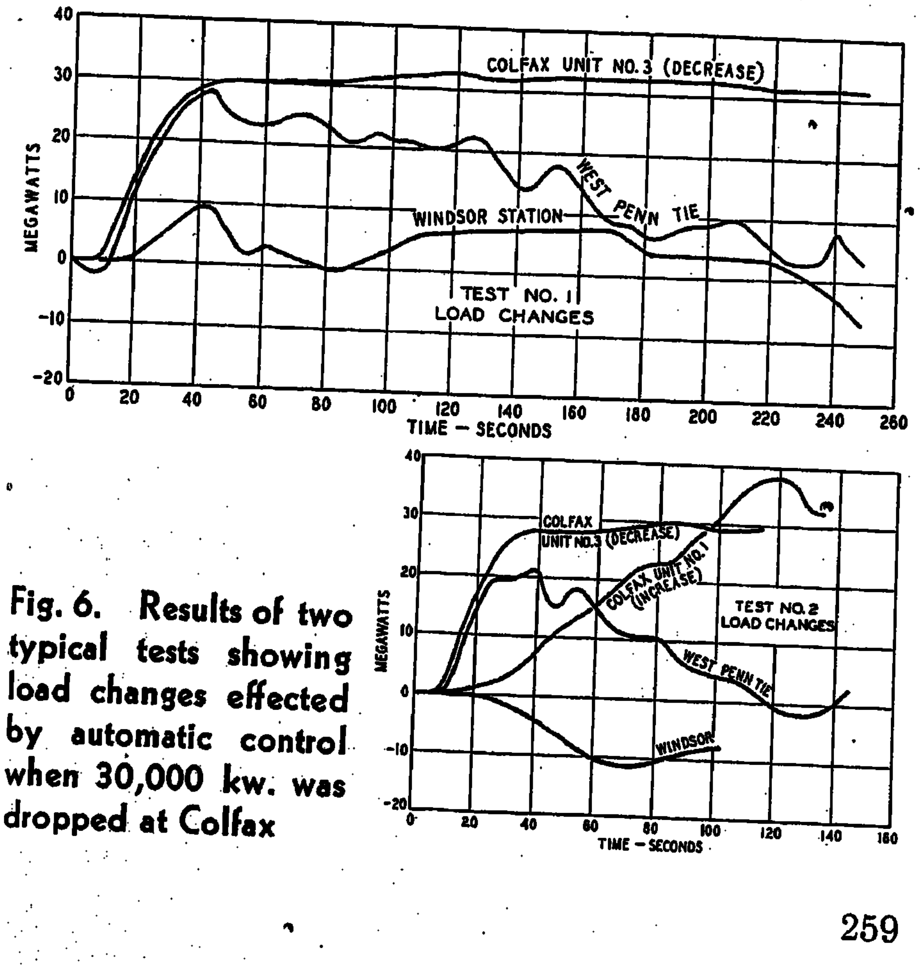


**Fig. 6. Results of two typical tests showing load changes effected by automatic control when 30,000 kw. was dropped at Colfax**

Both tests were similar except that the speed of response of the load regulator was increased in test No. 2. It may be noted that in this second test the load was dropped at Colfax station but was not picked up at Windsor. This was due to the latter station dropping load faster to compensate for load changes on its own system, and incidentally is a good illustration of the advantages of load diversity through interconnection.

## CONCLUSIONS

On the basis of the foregoing, it may be said that:

1. Automatic tie-line load regulators and program loading equipment have been developed to a commercial stage.
2. Tie-line load regulators on one system can be operated satisfactorily in conjunction with frequency regulators on a connected system.
3. Tie-line control may be used to reduce load fluctuations between interconnected systems.

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# Variable Ratio Frequency Converter

**Two synchronous-induction frequency converters with controllable frequency ratio and full automatic features were chosen to tie a 25-cycle and a 60-cycle system. Consideration of generation, loads, load cycles, and stability of both systems led to the selection of this type of unit.**

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Both of
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COINCIDENT and continual growth of the 25-cycle and 60-cycle systems of the Union Electric Light and Power Company created a series of problems which called for simultaneous solution. These requirements were essentially:

1. Need for additional 60-cycle prime capacity to meet a normal yearly increment in 60-cycle load.
2. Need for additional 25-cycle reserve capacity to supply overgrowth of a 25-cycle system load beyond the ability of a run-of-river hydroelectric plant and a small 25-cycle steam reserve plant to adequately handle it.
3. Recovery of annual loss of 60,000,000 kw-hr. in run-of-river hydroelectric plant due to deficiency in 25-cycle system load at times.
4. Need for 40,000 kva. in synchronous condenser capacity at St. Louis to operate on end of 136-mile, 60-cycle transmission line.
5. Improvement in 25-cycle system operation if a small amount of corrective kva. could be added at St. Louis end.

A coordinated study indicated that more efficient use of the generating ability of both systems would be possible if they were connected by adequate frequency converter capacity, at the same time securing the complete satisfaction of all but the first point above enumerated. Keokuk, while developed to a maximum capacity of 135,000 kw. as a run-of-river, 25-cycle, hydroelectric plant, was limited at times to a maximum capacity of 70,000 kw., so that the requirement of 60-cycle prime capacity could not be met solely by the installation of frequency changer capacity. However, the 60-cycle system, supplied entirely from steam plants, was being augmented by the addition of a huge storage hydroelectric plant at Bagnell, to satisfy the 60-cycle system demand.

Interconnection of two hydroelectric plants of different frequency by frequency converters has obvious advantages, but when additional system requirements may be satisfied in the same installation with only a minor increase in cost, the importance of such an installation is evident. It was determined that the frequency changers should have the following characteristics:

1. The set should be able to transmit power in both directions in order to provide additional capacity to the 25-cycle system in times of water power deficiency; also access to the 60-cycle system of an additional 60,000,000 kw-hr. annually from the 25-cycle hydroelectric plants. It was found that the transfer to 25 cycles to take care of the load requirements on this system thus could be made without additional investment in 60-cycle generating equipment.
2. The machine should have such characteristics as would provide interconnection between a fixed capacity 25-cycle generating system of 175,000 kw. and an increasing 60-cycle system capacity with a present rating in excess of 450,000 kw.
3. The 60-cycle end of the machine should combine approximately 50,000 kva. of synchronous condenser capacity for use in bringing Osage power into the St. Louis district.
4. Either end of the machine should be constructed to run separately in the event of diversity between the watersheds of the Keokuk plant and Osage plant requiring such operation. This might be required also in the interest of economy in operation.
5. Two machines of one-half capacity each would be preferable to one, because then failure of one machine still would permit adequate operation in most cases.

The required size of frequency converters was determined from load requirements. Two sets of 20,000-kw. rating were chosen as combining most suitably the requirements of load transmittal, spare capacity, and synchronous condenser capacity. The type of set to be used was the subject of considerable investigation. It was found that there were five types of machines available; namely,

1. The synchronous-converter frequency converter
2. The synchronous-synchronous converter

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Based upon "Interconnection of the 25- and 60-Cycle Systems of the Union Electric Light and Power Company" (No. 31-137) presented at the A.I.E.E. South West District meeting, Kansas City, Mo., Oct. 22–24, 1931.

3. The synchronous-induction converter
4. The fixed-ratio synchronous-induction converter
5. The variable-ratio synchronous-induction converter

The synchronous-converter frequency converter consists of two synchronous converters on independent shafts, one operating from each of the systems to be interconnected. All power transferred is received at one frequency, converted to direct current and reconverted to alternating current of the other frequency. The fact that this machine has never been built in large sizes definitely precluded its use in this case.

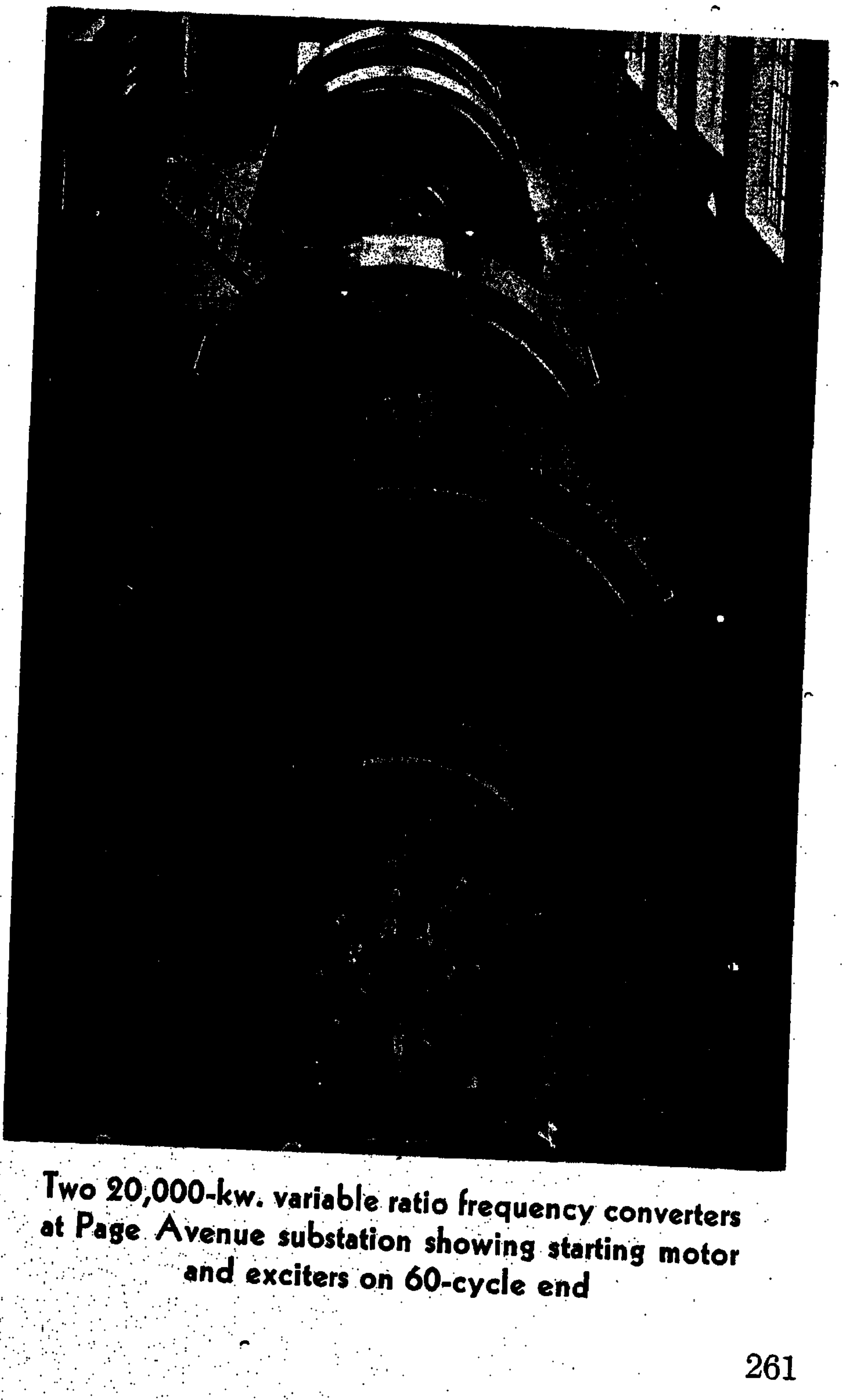
The synchronous-synchronous converter consists of two synchronous machines on a common shaft, one operating on each system. This machine is the one most commonly used. The frequency ratio is fixed and therefore the set constitutes a rigid frequency tie between systems within the limits of pull-out torque of the individual machines. The load is completely reversible, the load transmittal being determined solely by prime mover governing and not controllable at the set. Power factor control of both ends is available over a wider range than in any other type of set. The efficiency is high, preliminary estimates indicating that 95 per cent might be expected on a 20,000-kw. unit. This set is essentially simple in construction and operation and requires but few auxiliary machines. The paralleling of machines requires considerable precision in synchronizing. For example, starting from the 60-cycle end there is only one chance in twenty-four that the machine will "come up" right. Load division between sets is accomplished readily by stator shifting. Since machines of this type in the rating proposed already had been built no untried designs would be necessary.

Records indicated that the reliability of this type of set was good provided the machines were of sufficient capacity to withstand shocks incidental to system disturbances. The chief difficulty in applying this machine lies in determining the proper size of unit required. An examination of data available indicated that not less than from 10 to 25 per cent the capacity of the smaller system would be required. This application would require a set of from 18,000-kw. to 40,000-kw. capacity. Conservatively, it appeared that units of 30,000 to 40,000 kw. each would be required, and since load transmittal requirements did not justify units of this size, this type of converter seemed undesirable.

The synchronous-induction converter consists of a synchronous machine direct-connected to an induction machine of either the wound rotor or squirrel cage type. The frequency ratio of this set varies according to the load on the set and is not controllable at the set. The load is reversible if sufficient synchronous capacity is available to supply the exciting kilovoltampere of the induction machine, but there is considerable change in frequency ratio with change in direction of power flow. Load control is determined by prime mover governing. The set is relatively stable, the stability being determined chiefly by the pull-out torque of the synchronous machine. Power factor control is available on the synchronous end of the set but not on the induction end. The efficiency is relatively low. The set is simple in construction and operation and of good reliability.

The fixed-ratio synchronous-induction converter consists of a synchronous machine and a wound rotor induction machine with the rotor of the induction machine and the stator of the synchronous unit connected to the lower frequency system, with the stator of the induction machine connected to the system of higher frequency. This converter is sometimes called the "general transformer" since it can be arranged to transform phase, frequency, and voltage. A peculiar characteristic of this set is that it constitutes a voltage tie between systems of different frequencies in a manner analogous to a transformer on a single-frequency system. In several cases the set has been used to obtain certain advantages which this characteristic gives under particular circumstances. In the case at hand this feature was undesirable.

The frequency ratio of this converter is fixed by the design and is rigid. The load is reversible and the load control is obtained by prime mover governing. Stability is good and limited power factor control is available by a combination of transformer tap changing and synchronous machine field control. The efficiency is relatively high and operation is relatively simple although there is only one chance



Two 20,000-kw. variable ratio frequency converters at Page Avenue substation showing starting motor and exciters on 60-cycle end in ten of correct polarity and phase on the second unit. This type of machine has been reliable in service and has been built in large sizes.

The variable-ratio synchronous-induction converter consists of a synchronous machine direct-connected to a wound rotor induction machine provided with suitable regulating machines, the number and type varying with the particular manufacturer. The distinguishing feature of this set is that the frequency ratio is variable. Voltage and load disturbances are reflected through the set to a lesser degree than with other types. The load is reversible and the load control within the design limits of the set is accomplished at the set itself without dependence on prime mover governing. Stability is good, the maximum load transmittal being determined by the pull-out torque of the synchronous machine, the relative speed changes of the two systems, and the speed of operation of the regulating equipment. It is interesting to note that if the automatic regulating equipment is not working, a relative speed change of twice the slip of the induction machine is required to change from full load in one direction to full load in the other; whereas with fixed ratio types this reversal occurs with only a small phase angle change. In the synchronous machine power factor control can be obtained over a wide range and in the induction machine, over a limited range determined by economic design considerations. Efficiency is good although not so high as on synchronous-synchronous machines; the efficiency varies with variation in frequency ratio. Although simple of operation, the set is somewhat complex. Its main advantages lie in stability, ease of starting, and load control. The sets had been built in the size contemplated and component machines of larger size produced.

**The two 20,000-kw. frequency converters, showing the Scherbius regulating equipment for the 25-cycle induction unit in the foreground**

Based on this analysis it was decided to purchase two variable-ratio synchronous-induction converter sets, each set to be capable of transmitting 20,000 kw. from the 25-cycle to the 60-cycle system or vice versa with simultaneous and opposite variations in normal frequency of one-half cycle in each system; that is, each set was to be capable of transmitting full load from either system to the other throughout frequency variations from 24.5/60.5 to 25.5/59.5 cycles. This would permit a fairly wide variation of frequency in one system if that of the other were fixed, the range being affected by the direction of load transmittal because of the natural slip of the induction machine.

The machines, completely automatic in operation, are of the six-bearing horizontal type with adequate provisions for movement of stators on both of the large machines to permit easy maintenance or repair. A split coupling is provided between the machines, with the starting motor and d-c. exciters located on the 60-cycle end to permit independent operation of the 60-cycle unit as a synchronous condenser, if required. Each unit occupies an area of approximately 13 x 60 ft. The machines are of the semi-enclosed type, drawing filtered air from the room and discharging it into the basement. The ventilation requirements are 150,000 cu. ft. of air per min. per set.

The frequency converters in several months of operation have met their expected requirements fully. The average over-all efficiency has been approximately 90 per cent during the first six months' operating period, the normal load cycle requiring operation part of the day as 60-cycle generators, and the balance of the time as 25-cycle generators, supplying 25-cycle relay power.

It has been found that the inherent ability of the machine to change load gradually with system speed changes has been of marked benefit in stabilizing the systems. For example, with the set feeding the 25-cycle system, a voltage drop may cause the loss of considerable 25-cycle load with consequent speeding up of that system. The load reverses and the frequency is held to a small departure from normal. The occurrence of a short circuit on the 25-cycle system reduces the exciting voltage to a low value and consequently the decrement curve shows a very rapid drop after the first few cycles; this has the effect of holding the interrupting requirements on oil circuit breakers to a low value. The corrective capacity in the 25-cycle induction units varies from zero at full load to 16,000 kva. at no load and exerts a remarkable stabilizing influence on the 25-cycle voltage. The 60-cycle machines are equipped with high-speed excitation systems so that the 60-cycle voltage is held within close limits.

The machines as installed cannot be operated unless a 25-cycle exciting source is available, although minor modifications would permit d-c. excitation to bring up a dead system. In several cases where the 25-cycle bus voltage has been dropped to a very low value by faults close into the bus, the machines have resynchronized themselves without any difficulty. It is of interest that the voltage of the induction unit is always at the same frequency as the exciting source, but its value may vary through wide limits and it may be considerably out of phase with the system voltage. Consequently, the ability to resynchronize depends upon the action of the regulating equipment and the changes in relative system speeds during the interval when the bus voltage is very low.

# Abstracts

## Of Papers to Be Presented at the Providence District Meeting

INTERPRETIVE abstracts of all papers which at the time of this issue are definitely scheduled for presentation at the A.I.E.E. Providence District meeting (May 4–7, 1932) are published herewith. Papers presented at this meeting will not be available in pamphlet form, but in response to popular demand and within its space limitations, ELECTRICAL ENGINEERING subsequently may publish certain of these papers, or technical articles based upon them.

### The Parallel Type "Inverter"

By
F. N. Tompkins[1]

THE DEVELOPMENT of the thyratron or three-element hot-cathode gas-filled tube with grid-controlled arc has given electrical engineeing a new tool. Many interesting and valuable applications have been devised, among the most interesting of these being the "inverter." Its purpose is the inversion or changing of direct current to alternating current, the reverse process of the more usual rectification. With the advent of the thyratron with its high efficiency, low voltage drop, and its ability to handle the comparatively large amounts of power, the inverter gives promise of becoming of commercial importance.

Inverter circuits may be divided into two main types, series and parallel. While for the former types many data have been published and many different circuits have been devised, very little beyond the fundamental circuit has been given for the latter. The purpose of this paper is to present the results of a study of the parallel-type inverter which was undertaken to secure a better understanding of the function of each part and of the operation as a whole. There is presented the information necessary to make the operation of thyratron circuits understood. The principles of operation of the inverter are developed by means of simple diagrams, and from complete sets of oscillograms the actual operation is shown.

It is demonstrated that the method of operation differs from that usually assumed, inasmuch as the capacitor performs the function of giving the correct phase relation between the input current and the induced transformer primary voltage, rather than providing a sudden reversal of potential on the anode of the tube being stopped. This reversal is provided by the induced primary voltage. The effects of low power factor loads with both leading and lagging current are shown by oscillograms and the effects of improper circuit constants when operating at low power factor are given.

The output wave form under conditions of full load unity power factor is analyzed and it is shown that with the proper circuit constants the voltage wave is a fair approximation of a sine wave. For any given set of circuit constants the output wave forms change with the character and degree of loading. When reasonably good output wave forms are secured, the voltage regulation is poor but the efficiency is high. Changes in the circuit which give better regulation cause poorer wave form so that in the design of this type of inverter circuit a balance must be chosen between these two factors. Curves of efficiency and regulation, the latter showing the effects of different values of capacity, are given and briefly discussed. (Pamphlet copies not available.)

### Engineering Features of Phanotron Tubes

By
H. C. Steiner[2]
A. C. Gable[2]
H. T. Maser[2]

DURING the last few years vacuum tubes have found an ever-enlarging field in industrial applications, the more recent gas filled electron tubes providing the engineer with a tool even better suited to his needs. Among the outstanding engineering features of the gas or vapor filled electron tube (to which the name phanotron has been applied) are as follows:

1. The tubes are static devices, the complete functions of which are performed through the movement of electrons and ions.
2. The efficiency in controlling or converting power is high. Tube efficiency ranges from 95 per cent to over 99 per cent.
3. Control is flexible and the power required for control is small.
4. The speed of operations as a relay is extremely fast, and in addition, the tube may function cycle by cycle or intermittently without the wear that accompanies the operation of mechanical devices.
5. Noise and vibration are entirely absent.
6. Current carrying capacity is available in the range from a few milliamperes to several hundred amperes.

In practise the name phanotron has become associated with the two-element or simple rectifying tube. The phanotron tubes in which the starting of the conduction period is controlled electrostatically by the action of one or more grids have been termed thyratron tubes. The design, characteristics, and operation of these types of tubes are described in this paper, ratings being given.

Fundamentally, applications may be divided into two classes; namely, rectifiers converting alternating current into direct current with or without voltage control, and inverters changing direct current into alternating current. Oscillograms are given in the paper for a bi-phase rectifier with voltage control, supplying loads that are predominantly resistive, inductive, and capacitive. The operation of a single phase inverter is described and oscillograms are given for the voltage and current conditions of one of the tubes, the output voltage, and the commutating condenser current. (Pamphlet copies not available.)

### Subharmonic Frequencies Produced in Non-Linear Systems

By
W. M. Goodhue[3]

IN BRIDGE measurements, harmonics, due to a non-linear load being measured or due to the power supply may fail to be balanced at the same time the fundamental is balanced. This impresses on the detecting system a wave containing a large proportion of harmonics, or, at true fundamental balance, harmonics without fundamental component. The detecting system contains magnetic materials and may include a vacuum tube amplifier. Different observers have found errors which they traced to the apparent conversion of part of the harmonics into a fundamental component.

It is shown in the paper that a single non-linear device, such as a vacuum tube operating on a curved characteristic, usually converts parts of an input, consisting of third and fifth harmonics only, into a fundamental component. This is distinct from detector action which occurs at the same time and yields a second harmonic, and also from modulation which requires two stages of amplification, one acting as modulator and the other as detector.

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[3] Harvard University, Cambridge, Mass.

For moderate amplitudes, a Taylor's theorem expansion of the characteristic of the non-linear device is employed and resulting formulas for fundamental and harmonics tabulated for an input of two harmonics of arbitrary frequency, magnitude, and phase angle. The Taylor coefficients of the power series expansion which are involved in the resulting formulas are determined graphically, as the graphic method is more informative, less troublesome, and more accurate than attempting to obtain directly the cubic equation by a three point method, etc. The effect studied is essentially a third order effect.

For large amplitudes the method is entirely graphic, and even ordinary methods of wave analysis are not suitable due to the small fundamental and large harmonics. Graphic integration is employed and comparisons made of r.m.s. value, average value, and magnitude of fundamental. Also an example is worked out with an iron alloy (linking a coil) instead of the vacuum tube amplifier. Usually the effect with magnetic materials is further complicated by eddy currents and cyclic loop effects. (Pamphlet copies not available.)

# A General Theory of Systems of Electric and Magnetic Units

By
V. Karapetoff[4]

GENERALLY it is conceded that the present situation in regard to the electric and magnetic units is far from satisfactory, for the following reasons:

1. Two or three systems of units are in general use (C.G.S. and practical) at least two more are employed by some prominent writers (the Gauss system and the Heaviside-Lorentz system) and new ones are occasionally being proposed.

2. The absolute magnitudes of some units fixed by international agreement or in general use otherwise are considered as being too small or too large by some investigators who urge the adoption of smaller or larger units.

3. There is an appreciable disparity between the "absolute" C.G.S. units and the corresponding "international" units.

4. The physical dimensions of the electric and magnetic quantities are believed by some scientists to be different in different systems of units. Some physicists even believe it legitimate to assign an arbitrary physical dimension to a quantity; as, to assume absolute permeability for any medium to be a numeric.

In this paper it is pointed out that a system of electric and magnetic units may be shown to be characterized by five parameters; namely, a numeric $n$ which gives the ratio between the nominal density of electric displacement used in that system and the *true* density; a numeric $p$ which gives the corresponding ratio for magnetic flux densities; a physical conversion factor $k$ which converts a given volume of current into the corresponding magnetomotive force; the absolute permittivity $\kappa$; and the absolute permeability $\mu$. On the basis of these five parameters, the principal fundamental equations of electricity, magnetism, and electromagnetic waves are written in what is called the general system of units without assigning definite values to these parameters. It is shown also that the five parameters must satisfy the equation $vk = \sqrt{np/\kappa\mu}$ where $v$ is the velocity of propagation of electromagnetic waves in that particular medium to which $\kappa$ and $\mu$ refer; otherwise the five parameters may be chosen artibrarily.

By giving these parameters specific values, seven different systems of units are derived; namely, the electrostatic, the electromagnetic, the practical, the Gauss, the Heaviside-Lorentz, one which the author calls the compromise system, and the ampere-ohm system introduced by him some 20 years ago. The characteristics, the advantages, and the disadvantages of each system are briefly discussed, and it is shown how to deduce a new system of units from the general system.

At the end of the article a discussion is given on the physical dimensions of various electric and magnetic units. It is stated that four fundamental units are necessary for a system so that if certain length, mass, and time intervals are taken as three fundamental units, a fourth electric or magnetic unit must be added, for example, the permittivity or the permeability. In the ampere-ohm system, two mechanical fundamental units are used, the centimeter and the second; also two electrical units, the ampere and the ohm. Physical dimensions of $k$ are unknown. (Pamphlet copies not available.)

# A Proposal to Abolish the Absolute Electrical Unit System

By
E. Weber[5]

THE FUNDAMENTAL discovery that the ratio of the "absolute" electrostatic unit to the "absolute" electromagnetic unit of electric charge, predicted as velocity, was apparently identical with the velocity of light brought about an unforeseen confusion in the field of electrical units. The use of various absolute dimension systems expressing the electric and magnetic quantities by means of the three mechanical fundamental dimensions influenced the writing style of formulas and caused the introduction of arbitrary factors.

A veritable flood of articles and papers has been published in the important periodicals of the world, concerned either with a new system of electric and magnetic units or dimensions, or with a comprehensive basic system of mechanical units. None of them has succeeded as yet, because of the attitude of respect toward the classical "absolute" systems. This paper aims to prove conclusively the incorrectness of these classical dimension systems and to propose "natural systems" which, it is hoped, may finally settle the differences and put the electrical unit systems upon a sound basis.

The absolute dimension systems expressing the electric and magnetic quantities by the three dimensions of mechanics are shown to be incorrect since the consequent use of proper mathematical statements leads to impossible results. However, the definitions of the absolute units, as well as the "practical" units in electromagnetics have a sense quite independent of the dimension systems. It is shown that the simplest and, as it seems, apparently the only true solution is to extend the two mechanical dimensions systems, known as technical and physical systems, into the field of electromagnetics by adding a new fundamental electric dimension. This gives two electrical systems, the electrotechnical dimension system with all the practical units and the electrophysical dimension system with all the absolute units. (Pamphlet copies not available.)

# Performance Calculations on Induction Motors

By
C. G. Veinott[6]

THE MEANS given in this paper for calculating the performance of both single phase and polyphase induction motors is intended primarily for calculations from previously determined design constants. By actual trial the methods have been found to be very easy to learn and use even without a knowledge of induction motor theory, and are very rapid.

In the past many of the popular calculating methods for induction motors made use of various forms of circle diagrams, charts, families of curves, etc. Both methods developed in the present paper are arrived at by a simple straightforward use of complex algebra, and consist of the filling in of the blank spaces of a calculating sheet especially prepared for this purpose and which can be incorporated on the regular design sheet. The methods are inherently as accurate as the best methods proposed to date, and are more accurate than many of the older methods. Further, they are well suited to rough calculation, ordinary calculation, or exact calculation.

The single phase calculation method is based upon the cross-field theory, the principle being to set up and solve by the algebra of complex quantities three simultaneous equations for the currents in the three circuits of the motor; namely, primary circuit, transformer circuit of the rotor, and the secondary cross-field circuit. The new method is faster than previous graphic methods, and also is more accurate. The independent variable is the rotor speed.

The polyphase calculation method is based upon the equivalent circuit and the equivalent circuit is based upon the revolving field theory. The independent variable is the slip. As it is not necessary to compute the large number of curves required for some of the previous methods, an enormous amount of time and labor is saved. Furthermore, the method distinguishes between primary and secondary leakage. (Pamphlet copies not available.)

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# Measurement of Stray Load Loss in Polyphase Induction Motors

By
C. J. Koch[2]

FOR LACK of a satisfactory method of measurement, no provision is made for stray load losses in the A.I.E.E. standard efficiency tests for induction motors. These losses may amount to from 2 to 5 per cent in squirrel cage motors from 1 to 5 hp. in size, decreasing gradually with increase in motor rating until they are less than 1 per cent for motors of several hundred horsepower. Development of an easy method of measuring stray load losses would not only rectify this situation, but also would permit the losses themselves to be studied more intensively and perhaps ultimately to be reduced greatly.

All methods of measuring stray load losses may be classified as either direct or indirect. Indirect methods aim to measure the total loss in the motor, substraction of the conventional losses yielding the stray load loss. Best known among the various indirect methods perhaps is the input-output method. Direct methods of measuring these losses are based upon the following procedure: Either the rotor or stator winding is excited by direct current with the unexcited winding short-circuited; the rotor then is revolved at synchronous speed and the power required to do this is measured. The stray load loss then is determined by subtracting from the power required to drive the rotor in this manner, the friction and windage losses, and also an amount of power equal to the $I^2R$ loss produced by the fundamental frequency current in the unexcited member.

Upon the basis of a series of tests made on both slipring and squirrel cage motors of different sizes, the following methods are recommended:

**Slipring Motors**

1. Measure the power required to drive the motor at synchronous speed with the primary winding short circuited and sufficient d-c. excitation applied to the secondary winding to cause full load current to circulate in the primary; designate the power required as $W$. From the d-c. resistance (making any corrections necessary for differences in temperature) determine the primary $I^2R$ loss and designate this as $T$.

2. Repeat the test just outlined, with the primary current equal to the magnetizing current, and determine the rotational power required and the $I^2R$ loss; these latter are designated $W_o$ and $T_o$, respectively.

3. The stray load loss, then, is equal to $W-W_o-T+T_o$.

**Squirrel Cage Motors**

1. Apply d-c. excitation to the stator using two of the stator terminals and leaving the third open; the amount of direct current required is 1.225 times the full load alternating current per terminal. Under these conditions determine the power required to rotate the rotor at synchronous speed; this is designated $W$.

2. With the rotor at standstill apply to the stator balanced polyphase voltages of normal frequency and of sufficient value to produce full load current per terminal, and measure the starting torque thus produced. A check on the correctness of the torque obtained is given by the fact that its value expressed in synchronous watts must be somewhat less (usually from 5 to 20 per cent) than the stator watts input less the stator copper loss as calculated from d-c. resistance. Then T = Synchronous watts torque − 0.142 × Syn. Speed (r.p.m.) × Torque (lb.-ft.)

3. Repeat the test just described, determining $W_o$ with d-c. excitation equivalent to normal a-c. magnetizing current and calculate

$$T_o = \mathrm{T}\left(\frac{\text{Magnetizing Current}}{\text{Full Load Current}}\right)$$

4. The stray load loss is then equal to $W - W_o - T + T_o$

In practise, the starting torque varies closely as the square of the primary current. It is desirable therefore to measure the value of $T$ at only one value of current, selected to obtain the greatest accuracy of test, and to obtain the values of $T$ at other points by proportionality. The best value of current to select for this test will depend somewhat upon the type and size of motor. If the current is too large, overheating takes place and errors arise due to incorrect determinations of conductor temperature. However, if too low values of current are used, the small torque produced in comparison with the static friction makes accurate values difficult to obtain. It is recommended that full load current normally be used for squirrel cage and ball bearing motors, while values of 150 per cent full load current are recommended for normal use on sleeve bearing motors of less than 25 hp.

It is suggested that, after confirmation or modification by other investigators, the methods outlined be taken as a basis for revision of the A.I.E.E. standards, such revision to require the inclusion of induction motor stray load losses in efficiency determination. (Pamphlet copies not available.)

# Torque-Angle Characteristics of Synchronous Machines Following System Disturbances

By
S. B. Crary[2]
M. L. Waring[2]

THE DETERMINATION of the behavior of synchronous machines during transient conditions subsequent to a system disturbance is becoming increasingly interesting and important. In determining this behavior it is essential to know the torque-angle characteristic of the given machine under conditions resulting from disturbances of various sorts. The most important of such disturbances are variations in mechanical torque, excitation voltage, amount of external reactance, and system voltage. System voltage may vary in either magnitude or angular position.

Some of these disturbances already have been treated by various authors. It is the purpose of the first part of the present paper to establish general equations from which may be derived specific equations. Starting with the fundamental relations already developed, general equations are derived for the positive phase sequence torque of a synchronous machine subsequent to the following:

1. Switching in or out of a connecting line.
2. Occurrence of a balanced three phase system fault.

The evaluation of the torque characteristics following such disturbances is of particular importance in the determination of transient stability limits, and a step-by-step method of calculation is given so that the electrical torque of a machine having any number of rotor circuits can be determined at any time of its swing. The formulas and step-by-step method presented make it possible to predetermine the effects of amortisseur windings and high speed excitation. No attempts, however, have been made to draw any general conclusions as to the effect of these two factors.

In the second part of the paper an actual case of switching out of a connecting line is calculated, and the results compared with field tests taken on the system of the New York Power and Light Corporation. These tests are described in the companion paper, "Field Tests to Determine Damping Characteristics of Synchronous Machines." Good agreement between the calculations and test results is shown. (Pamphlet copies not available.)

# Field Tests to Determine the Damping Characteristics of Synchronous Generators

By
F. A. Hamilton, Jr.[2]

PRACTICAL system tests of the damping action of generators with and without low resistance damper windings, but otherwise identical, have been made. The effects of normal variations of generator field circuit resistance, field current, and loading were investigated, and data for checking calculated machine constants also were obtained. The results of the tests presented in this paper are valuable from a quantitative, as well as from a qualitative standpoint.

The field tests proved useful in providing graphic evidence of phenomena not well understood, and in obtaining data to verify available methods of analysis and upon which to build new methods of calculation and extension of existing theory.

Low resistance damper windings were found quite definitely to assist the rapid smoothing out of balanced disturbances resulting from the switching in or out of lines, synchronizing, load changes, or the tripping of loaded generators, and three phase short circuits. The test results indicate that generator field circuit resistance and generator field current may be varied within normal limits without greatly affecting the generator damping characteristics. Also, the test data verified methods of calculation presented in the companion paper, "Torque-Angle Characteristics of Synchronous Machines Following System Disturbances." (Pamphlet copies not available.)

## Design of Capacitor Motors for Balanced Operation

By
P. H. Trickey[6]

THE PRESENT methods of calculating the full load performance of capacitor motors are quite long and tedious. A simple convenient method of calculating full load conditions is given in this paper, including the necessary theory and formulas.

It is agreed generally that a capacitor motor should be designed to operate under nearly balanced conditions at full load. This means that there shall be no transfer of power from one phase to the other and the rotor current shall be balanced. With such a design, each phase produces equal flux and the rotor operates as if it were in a two phase stator. The theory presented in this paper is based upon balanced conditions, the method being useful only when the starting torque required is not too great. In many cases the starting torque requirements determine the winding, and the motor must operate slightly unbalanced at full load, with the resultant circulating current and lowered efficiency. (Pamphlet copies not available.)

## The Electro-Matic Traffic Dispatching System

By
H. A. Haugh, Jr.[8]

VEHICLE actuated traffic dispatching systems may be used by which the traffic in a given area controls itself. By this means the duration of the green light period at any intersection is in proportion to the volume of traffic on each approach. A smooth flow of vehicles is produced which uses the intersection efficiently.

This system of traffic control consists of three main parts; namely, the detectors, the signal lights, and the dispatcher. The detector may be any one of several types, such as a mechanical switch located in the pavement, an electromagnetic unit, or a beam of light which will be interrupted by approaching vehicles. The mechanical type has been found to be the most practical.

This dispatching device for this type of system must be of extreme flexibility, and the timing of the signal light cycle must constantly change to meet the irregular demand of traffic. This operation is secured by a group of time-delayed relays, combined with a switching mechanism. The resulting operation is similar to that which would be secured by having a traffic policeman at each corner, and the speed and amount of traffic, length of time which a car has to wait, and such factors, all are taken into consideration. The right-of-way is yielded to cross street traffic when the intersection is clear, and even when it is not clear if the cross traffic has waited for a predetermined period. However, moving traffic is never interrupted unless the right-of-way has been called to the cross street by waiting traffic or by a "pedestrian period." (Pamphlet copies not available.)

## The Flexible Progressive Traffic Signal System

By
H. I. Turner[7]

A FLEXIBLE progressive traffic signal system usually makes it possible to time signals so that traffic may move east and west, as well as north and south, at predetermined uniform speeds without being obstructed by a "stop" signal after once having passed a "go" signal. The planning of such a system is a matter that requires most intelligent study and one which yields results well worth the effort. Traffic-actuated equipment seldom can be justified over pre-timed equipment, as in a great majority of congested districts the coordination of the movement of traffic through the entire district is of incomparably greater importance than the most efficient movement of traffic at any few intersections taken by themselves.

Two general types of systems are used for planning service: the first employing a central office type controller with no timing devices located at the individual intersections, and the second, that which employs a master controller at a center point and an individual controller at each intersection. All of these controllers must have facilities for adjusting the time of each cycle of operation of the signals at any intersection from a central point, the percentage of the cycle taken by "go" and "stop" signals must be adjustable over a wide range and independently, and the start of the cycle of operation at any one intersection should be completely adjustable.

The following features are important in any flexible progressive control device:

1. Minimum maintenance expense and service interruptions.
2. Facilities for manual control.
3. Facilities for shutting down the signals at each local controller and from a central point by merely throwing a switch.
4. Adjustments which can be understood easily and made over a wide range.
5. The duration of the amber light should not increase or decrease when the total time cycle is changed.
6. Means should be provided for exhibiting emergency signals by control from a central point.
7. Means should be provided for accommodating traffic during times of the day when it is very heavy on a particular street. (Pamphlet copies not available.)

## A Recent Development in Traffic Control

By
H. W. Vickery[9]
V. W. Leonard[9]

A TIMING device containing new features and having extremely wide ranges of adjustment recently has been developed as a means for meeting the problems encountered in controlling present day vehicular traffic.

In the timer, a means is provided to give three progressive relations of the signals; thereby, the progressive relation can be changed remotely to give, for example, ideal progression of traffic into a city in the morning, and out in the late afternoon, with average progression in both directions at other hours of the day.

The timer is driven by a synchronous motor. Thus, accuracy of timing and timer settings is assured. A gear shift unit in which the gears can be shifted manually or from a remote point gives provision for changing the total time cycle. A solenoid operated drum containing a predetermined arrangement of cams opens and closes the signal light circuits. Any of the modern color sequences can be obtained by proper arrangement of the cams on the drum. Momentarily, by keys in a cycle percentage dial, a revolving switch is closed a given number of times each cycle. Thus, impulses are supplied to the drum solenoid and the drum is advanced through the various periods of the color sequence. By proper arrangement of the keys any desired percentage adjustment of these periods can be obtained.

A multi-contact relay in each timer, operated over the same wires used for remote shifting of the gears, gives provision for remote control of shut down, flashing amber, and fire control. (Pamphlet copies not available.)

## The Traffic Flow Regulator

By
C. H. Bissell[10]
J. G. Hummel[10]

THE PRACTISE of assigning a definite period for the red and green lights of each traffic signal, and keeping these periods constant throughout the day and week, is subject to serious criticism. Needless delays and congestion are caused, and the obedience of motorists to traffic signals in general may be broken down.

Traffic surveys have demonstrated that there are very definite traffic peaks and valleys for each week day as well as for Saturdays and Sundays. Experience has shown that these variations occur with definite regularity. It has not been found practical or economical to send out officers to change the timing on every signal light. Also, the system of some sort of an electrical or mechanical device to record the amount of traffic and adjust the timing signals accordingly, entails an expense which cannot be justified.

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[7] Eagle Signal Corp., Moline, Ill.

[8] Automatic Signal Corp., New Haven, Conn.

[9] Genl. Elec. Co., W. Lynn, Mass.

[10] Crouse-Hinds Co., Syracuse, N. Y.

A traffic flow regulator has been developed to vary the timing automatically through any predetermined cycle. For example, the device may be set to give a different signal at each of a large number of periods throughout the day, and the setting may be varied for different days of the week. In addition, certain special conditions frequently are encountered, and for these the timing device allows compensation. A system of extreme flexibility is thus secured. (Pamphlet copies not available.)

# Double Conductors for Transmission Lines

By
H. B. Dwight[11]
E. B. Farmer[11]

FOR OVERHEAD transmission lines, double conductors, consisting of a second conductor hung a few inches below the first by metallic hangers, present a number of advantages over one larger conductor. With this double construction, the two conductors are electrically in parallel and form one effective conductor of large cross-section without increasing the number of insulators or crossarms. In some cases where there is a mechanical margin of safety, it may be found desirable to add a second conductor to the present single conductor.

Among the advantages which may be secured by the use of double conductors are: a reduction of 20 per cent or more in reactance, almost entire elimination of skin effect, an increase in current carrying capacity of nearly 30 per cent, an increase in corona voltage of from 10 to 25 per cent, and in some cases the opportunity to add to the conductivity and power rating without scrapping the old conductor. The advantages are to be balanced against the extra cost due to mechanical features including hangers, increased cost of stringing, and additional wind and ice load. Since the increase in ice load is possibly the greatest disadvantage, the use of double conductors is of greatest interest to southern districts where ice load is not encountered.

In this article, formulas are given for the calculation of the electrical characteristics of double conductor transmission lines, which enable comparisons with other types to be easily made. (Pamphlet copies not available.)

# Three Phase Multiple Conductor Circuits

By
Edith Clarke

DURING the past year, the subject of power transmission by multiple conductor circuits has received considerable attention. Therefore the formulas and estimating curves given in this paper may be of interest.

Formulas are developed for the inductance and capacitance to neutral per phase and the approximate corona starting voltage of perfectly transposed multiple-conductor three-phase transmission lines having any number of conductors per phase.

For certain special arrangements of the conductors, curves are given for the 60-cycle reactance, capacity susceptance, and corona starting voltage. Throughout their practical range these curves show the effect of variations in conductor diameter, spacing between phases and between conductors of the same phase. Two, three, four, and five conductors per phase are considered.

A comparison is made of multiple and single-conductor circuits with respect to charging current, voltage at no load, power which can be carried with the same voltage drop, and stability. (Pamphlet copies not available.)

# The Solution of Circuits Subjected to Traveling Waves

By
H. L. Rorden[12]

THE EFFECT of traveling waves upon terminal apparatus usually is most easily solved by means of Heaviside's operational calculus. Solutions have been given previously for various combinations of impedances that may be encountered in service, by considering such impedances to be contained in simple circuits. These are intended to approximate the general conditions of a transmission system. However, a purely mathematical analysis of such an involved nature often is looked upon skeptically and experimental variation of such calculation therefore is valuable.

It is the major purpose of this paper to illustrate the accuracy with which mathematical solutions of traveling wave theory are substantiated by test results. For this purpose a transmission about 2 miles long was used, this line consisting of parallel conductors placed 8 ft. apart and forming a loop so that both ends terminated at the laboratory where both the lightning generator and the cathode ray oscillograph were located. Various other arrangements were used including the direct application of the lightning waves to impedances and transformers.

Much valuable information has been obtained relative to the wave shape and other peculiarities of traveling waves. Many irregularities exist in these waves, but generally the waves may be reproduced to a sufficient degree of accuracy that their effect may be determined both analytically and experimentally. It was found that in general the test results checked the calculations very precisely. The relative importance of the various factors affecting traveling waves also are discussed, and it is pointed out that certain of these may be neglected. (Pamphlet copies not available.)

# Corona Limit, Transmission Characteristics, and Method of Loading Multiple Conductor Lines for Very High Voltages

By
C. A. Boddie[13]

THE OBJECTS of this paper are to discuss a simple and practical method by which the present transmission voltages may be increased greatly and to point out a method of avoiding the detrimental effects of the immense charging currents attendant on the use of very high voltages. The most formidable natural limitation which prevents raising line voltages is the formation of corona, and the paper is concerned chiefly with the overcoming of this limitation. This may be accomplished by the proper method of increasing conductor diameter and using multiple conductors. The conclusions brought out by this paper are as follows:

Transmission lines may be built for considerably higher voltage than those at present used, and the same economies available through the use of higher voltages apply to voltages above 220 kv. as apply below that value. No very serious difficulties may be expected in going to the higher voltages. Multiple conductor lines lend themselves naturally to use at very high voltages, and line charging currents may be taken care of easily by introducing air gaps in the raising and lowering transformers or by use of properly designed loading coils. Also, loading coils assist greatly in switching.

When large blocks of power are to be transmitted it is always most economical to push the line voltage up to the point where a single circuit will transmit all the power. This may always be done however great the power. The question of duplicate lines as affecting the continuity of service may in some cases tend to modify this conclusion, but in general the fewest possible number of circuits gives the most economical system. Improvement in the methods of operating large three phase lines will minimize the necessity for spares and emphasize the foregoing conclusion. (Pamphlet copies not available.)

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[11] Mass. Inst. of Tech., Cambridge, Mass.

[12] Genl. Elec. Co., Pittsfield, Mass.

[13] Boddie Electro Physical Laboratories, Wilkinsburgh, Pa.

# News
## Of Institute and Related Activities

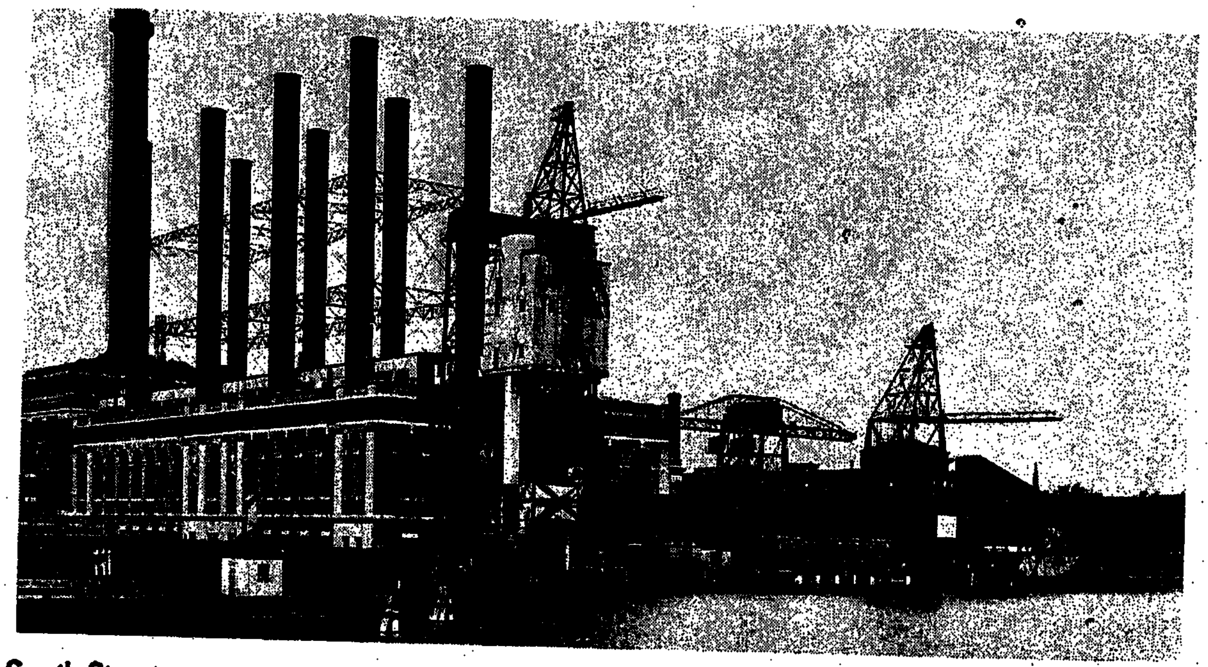
# North Eastern District to Meet at Providence

THE EIGHTH annual meeting of the North Eastern District of the A.I.E.E. will be held at Providence, Rhode Island, May 4–7, 1932, with headquarters at the Providence Biltmore Hotel. The committee has arranged an attractive program consisting of four technical sessions, inspection trips, a banquet, entertainment features, and a special program for the ladies. Another important feature of the meeting will be the student program scheduled for Friday, May 6. The technical sessions cover a variety of subjects. There will be a symposium on traffic control, a session arranged by the committee on electrical machinery, one by the committee on power transmission and distribution, and a session on selected subjects.

Providence, the capital of Rhode Island and the southern gateway to New England, enjoys exceptional shipping facilities to all parts of the world. Situated at the head of Narragansett Bay, 30 miles from the ocean, it occupies a strategic position as a port for both foreign and domestic commerce as well as a point of inland distribution; it is the second largest oil distributing port on the Atlantic seaboard. The city, itself, has a population of approximately 350,000, and within 15 miles of the city hall there are more than 700,000 inhabitants. The community enjoys 59 parks and playgrounds, the Roger Williams Park with its chain of lakes being considered one of the most beautiful parks in the country.

Providence is the home of Brown University established in 1664 and seventh in age among American colleges with an enrollment of approximately 2,200 students and a faculty of 200. Pembroke College for women is a part of the university. Providence College, the Rhode Island College of Education, the R. I. School of Design, and the R. I. College of Pharmacy all are located here. R. I. State College is at Kingston.

Industrially, Providence ranks high; it is the center of a state which has 55.1 per cent of its workers engaged in machine trades. The Brown and Sharpe Mfg. Co., makers of tools, the Nicholson File Co., American Screw Co., and Gorham Mfg. Co., makers of sterling silverware, all located in this city, are the largest in the world in their respective fields. The rubber industry also has good representation by seven large plants producing rubber footwear, medical goods, and novelties. Some of the largest plants of the U. S. Rubber Company are located here.



South Street generating station of the Narragansett Electric Company, Providence, one of the largest steam plants in New England. The installed generating capacity is 225,000 hp.

The Narragansett Electric Company, largest unit in the New England Power Association, serves most of the entire central and southern sections of the state, the southern part being served through a subsidiary company, the South County Public Service Company. The Blackstone Valley Gas and Electric Company serves the northern section and the Newport Electric Corporation the islands of Rhode Island and Conanicut. A network of transmission lines, steam and hydroelectric stations give to Rhode Island the benefit of an abundant supply of electric current. The Providence Gas Company established in 1848 serves about 82,000 customers in Providence and suburbs.

### ENTERTAINMENT FEATURES

Wednesday night will witness the "Gathering of the Clans." Provision will be made for informal get-togethers and reunions, card tables will be available, and supper dancing may be enjoyed in the Venetian Room of the Providence Biltmore Hotel.

Sock and Buskin, the dramatic organization of Brown University, is endeavoring to arrange a performance on Friday evening for the Institute members and ladies.

To the golf playing members there will be available the facilities of the Wannamoisett Country Club, a ranking course over which the Professional Golfer's Association in 1931 played off their championship. Tennis facilities will also be provided.

### BANQUET

The banquet will be held Thursday evening in the main ballroom of the Biltmore. Prof. William H. Kenerson of the mechanical engineering department of Brown University will act as toastmaster and William S. Lee, junior past-president of the Institute, will be the speaker of the evening. Both President C. E. Skinner and Vice-President I. E. Moultrop will address the meeting, and the District prizes awarded for papers given in 1931 will be presented. At the conclusion of these ceremonies there will be dancing until 1:00 a.m.

### LADIES' ENTERTAINMENT

The committee for the entertainment of the ladies has prepared what should be an interesting program. It is planned to spend one afternoon in colonial Rhode Island, a large share of which still maintains its original appearance. This will be rounded out with a tea in the historic mansion now housing the Handicraft Club. A luncheon and bridge at one of the city or nearby country clubs also is contemplated. Trips to Roger Williams Park and other points of local interest will be arranged. Golf courses and tennis courts will be made available to all ladies interested in those departments of sport.

Inspection Trips

Inspection trips are scheduled on the program for Thursday afternoon and Saturday morning. In addition, a special trip for the students is being arranged for Friday afternoon.

Full details of all trips will be announced later and posted on the bulletin board. Among the places of interest which may be visited are a generating station and substations of the Narragansett Electric Company and the Gorham Manufacturing Company. The engineering laboratories of Brown University will also be open for inspection. Several other trips also are being arranged.

Registration

All who plan to attend the meeting should register in advance by mail. A card for this purpose will be sent to all members of Districts 1 and 3 before the meeting. Members should complete their registration after arrival at the meeting so as not to miss the opening session. There will be a meeting fee of one dollar for members and fifty cents for students.

All who register in advance will be sent a road map of Rhode Island and a map of the downtown section of Providence showing headquarters and convenient parking and garage facilities.

Hotel reservations should be made by writing directly to the hotel preferred. Rates for the headquarters hotel, Providence Biltmore, as well as several other recommended hotels are given in the accompanying table.

## Technical Program

Abstracts of all papers to be presented at the meeting are given on adjoining pages. Pamphlet copies of these papers are not available.

All technical sessions and the opening of the meeting will be held at the Providence Biltmore Hotel. Breakfast meetings will be announced on the bulletin board near registration headquarters and will be held daily for authors and chairmen of the technical sessions scheduled for the day.

### Wednesday, May 4

**9:00 a.m.—Registration**

**9:30 a.m.—Opening Session**

Opening address—I. E. Moultrop, vice-president, North Eastern District, A.I.E.E.

Welcoming remarks—James E. Dunne, mayor of Providence

Greetings—Leighton T. Bohl, president of Providence Engineering Societies

**Selected Subjects—Prof. V. Bush, *chairman***

Parallel Type Inverter, F. N. Tompkins, Brown University

Engineering Features of Phanotron Tubes, H. C. Steiner, A. C. Gable, and H. T. Maser, General Electric Co.

Subharmonic Frequencies Produced in Non-Linear Systems, W. M. Goodhue, Harvard University

A General Theory of Systems of Electric and Magnetic Units, V. Karapetoff, Cornell University

A Proposal to Abolish the Absolute Electrical Unit Systems, E. Weber, Brooklyn Polytechnic Institute

**2:00 p.m.—Electrical Machinery—P. L. Alger, *chairman***

Performance Characteristics of Induction Motors, C. G. Veinott, Westinghouse Electric & Mfg. Co.

Stray Load Loss in Polyphase Induction Motors, C. J. Koch, General Electric Co.

Torque-Angle Characteristics of Synchronous Machines Following System Disturbances, S. B. Crary and M. L. Waring, General Electric Co.

Field Tests to Determine the Damping Characteristics of Synchronous Generators, F. A. Hamilton, General Electric Co.

Design of Capacitor Motors for Balanced Operation, P. H. Trickey, Westinghouse Electric & Mfg. Co.

**8:00 p.m.—Informal Reception**

### Thursday, May 5

**9:00 a.m.—Symposium on Traffic Control—H. M. Turner, *chairman***

Address: The Broader Aspects of Traffic Control, E. P. Goodrich, president, Traffic Institute

The Flexible Progressive Traffic Signal System, H. I. Turner, Eagle Signal Corp.

Electromatic Traffic Dispatching System, H. A. Haugh, Jr., Automatic Signal Corp.

Recent Developments in Traffic Control, H. W. Vickery and V. W. Leonard, General Electric Co.

Traffic Flow Regulator, C. H. Bissell and J. G. Hummel, Crouse-Hinds Co.

**12:00 m.—District Executive Committee Luncheon**

**2:00 p.m.—Inspection Trips**

**6:00 p.m.—Banquet**

### Friday, May 6

**9:00 a.m.—Student Technical Session**

Address—William S. Lee, junior past-president, A.I.E.E.

Awarding of Prizes

**12:00 m.—Luncheon Conference of Counselors and Delegates**

**2:00 p.m.—Student Inspection Trip**

**2:00 p.m.—Transmission—P. H. Chase, *chairman***

Double Conductors for Transmission Lines, H. B. Dwight and E. B. Farmer, Massachusetts Institute of Technology

Three Phase Multiple Conductor Circuits, Edith Clarke, General Electric Co.

The Solution of Circuits Subjected to Traveling Waves, H. L. Rorden, General Electric Co.

Corona Limit, Transmission Characteristics and Method of Loading Multiple Conductor Lines Designed to Operate at Very High Voltage, C. A. Boddie, Boddie Electro Physical Labs.

**7:30 p.m.—Entertainment Feature**
**(To be announced at the meeting)**

### Saturday, May 7

Meeting rooms have been arranged for continued sessions of any part of the technical program.

The local committee is planning an all-day trip, details of which will be announced later.

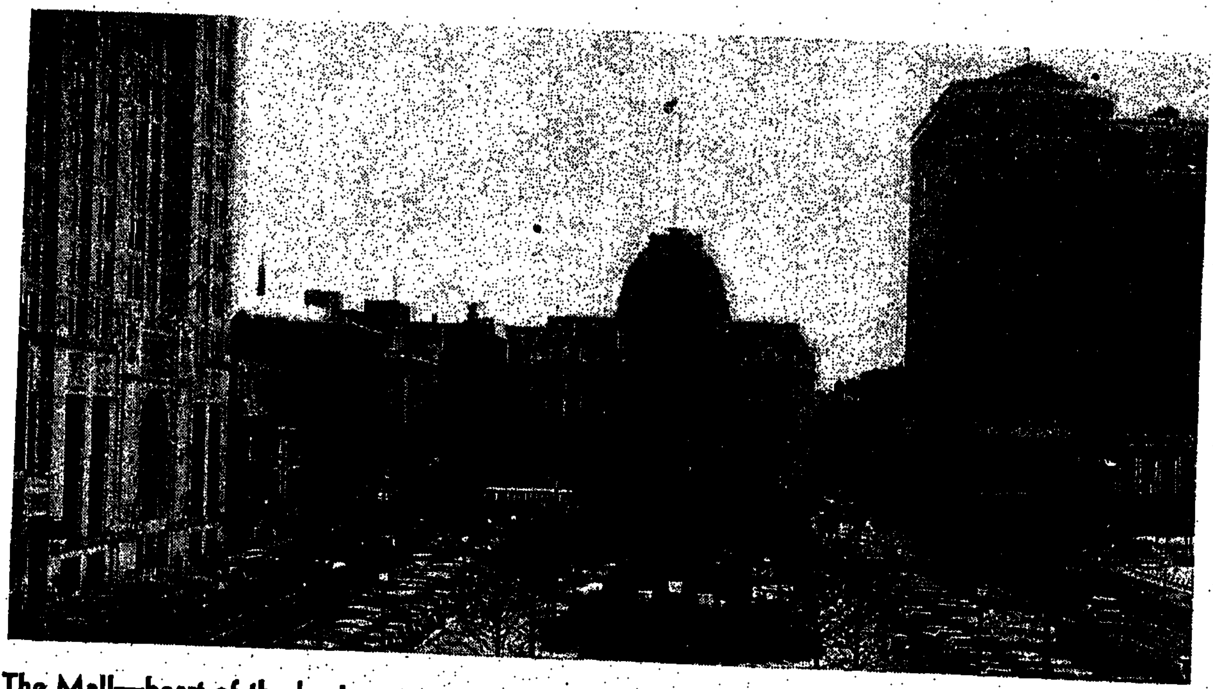
Rules on Presenting and Discussing Papers

At the technical sessions papers will be presented in abstract, ten minutes being allowed for each paper unless otherwise arranged or the presiding officer meets with the authors preceding the session to arrange the order of presentation and allotment of time for papers and discussion.

Any member is free to discuss any paper when the meeting is thrown open for general discussion. Usually five minutes is allowed to each discusser. When a member signifies desire to discuss papers on other subjects or groups he shall be permitted a five-minute period for each subject or group.

It is preferable that a member who wishes to discuss a paper give his name before hand to the presiding officer of the session at which the paper is to be presented. Copies of discussion prepared in advance should be left with the presiding officer.

Each discusser is to step to the front of



**The Mall—heart of the business section of Providence—looking toward the city hall from the steps of the Federal Building. The Providence Biltmore Hotel is on the right, the Union station being slightly further to the right**

the room and announce, so that all may hear his name and professional affiliations.

### Committees

**District Meeting**—I. E. Moultrop, *chairman*, vice-president, North Eastern Dist.; A. C. Stevens, secretary-treasurer, North Eastern Dist.; C. W. Henderson, chairman, Student Counselors, North Eastern Dist.; O. W. Briden, R. W. Graham, W. S. Maddocks, J. P. McCann, R. G. Warner, and F. C. Young.

**Local**—W. S. Maddocks, *chairman;* O. W. Briden, *secretary-treasurer;* R. W. Herrick, Mrs. R. W. Herrick, J. W. Keeney, L. P. Kenneally, and J. C. B. Washburn.

**Hotels and Registration**—O. W. Briden, *chairman;* R. W. Allen, L. P. Breault, A. S. Kirk, E. E. Nelson, R. C. Patton, O. E. Sawyer, F. N. Tompkins, and R. J. Underwood.

**Finance**—J. W. Keeney, *chairman;* W. W. Broadbent, and O. W. Briden.

**Inspection Trips and Transportation**—J. C. B. Washburn, *chairman;* P. W. Browers, P. L. Carroll, E. B. Curdts, R. W. Eaton, L. E. Fogg, J. E. Hall, C. H. Parker, and G. U. Parks.

**Sports, Entertainment, and Banquet**—R. W. Herrick, *chairman;* E. S. Esty, M. V. Gardner, I. W. Knight, J. J. O'Brien, W. C. Slade, T. G. Webber, and J. W. Young.

**Student Program**—C. W. Henderson, *chairman;* W. B. Hall, and L. W. Hitchcock.

**Publicity**—L. P. Kenneally, *chairman.*

**Ladies Entertainment**—Mrs. R. W. Herrick, *chairman;* Mrs. R. W. Eaton, Mrs. W. S. Maddocks, Mrs. W. C. Slade, and Mrs. J. W. Young.

| Hotel | Single | Double |
|---|---|---|
| Providence Biltmore | $3.50–$7.00 | $5.50–$10.00 |
| (With bath and shower) | $5.00–$8.00 | $7.00–$12.00 |
| Narragansett | $2.50* | $4.00* |
| | $3.00–$3.50 | $4.50–$5.00 |
| Crown | $2.00* | $4.00* |
| | $3.00 | $6.00 |
| Wayland Manor (Family Hotel) | $3.50 | $5.00 |
| Apartments, 3 or 4 persons, $2.50 per person | | |

* Rooms without bath.

# Great Lakes District
## Milwaukee Meeting Exceeds Expectations

As a fitting tribute to the various committees that planned and handled the meeting of the Great Lakes District (No. 5) held at the Pfister Hotel in Milwaukee March 14–16, the attendance and participation in the meeting activities exceeded even the fondest expectations of those in charge of the work. The whole program of activity for the meeting was well conceived, and organized for the greatest convenience of those attending. Technical sessions were held only in the forenoons, Monday, Tuesday, and Wednesday, with the single exception of the student technical session which was held Monday afternoon. An attractive and carefully managed program of inspection trips provided those in attendance with afternoon activities which served as recreation as well as to acquaint the participants with the interesting features of Milwaukee industries. The popularity of this program was emphatically attested to by the registration of 552 members, Enrolled Students, and guests.

With credit to T. N. Lacy of Detroit, Mich., and to A. G. Dewars of Minneapolis, Minn., respectively vice-president and secretary for the Great Lakes District, for the coordination of District activities in connection with the meeting, full credit for the untiring prosecution of the details so essential to meeting success, goes to F. A. Kartak, dean of engineering of Marquette University, Milwaukee, vice-chairman of the District meeting committee, and to the committee organization which functioned under his direction. The general committee, in addition to those already mentioned, included C. C. Knipmeyer of Terre Haute, Ind., student counselor for the Great Lakes District; J. F. H. Douglas, Fraser Jeffrey, C. H. Krueger, and E. U. Lasson, of Milwaukee, Wis.; F. R. Innes and F. H. Lane, of Chicago, Ill.; N. H. Blume and L. C. Larson, of Madison, Wis.; and C. E. Skroder of Urbana, Ill.

### Technical Sessions

The Milwaukee technical program consisted of sixteen papers divided among three sessions held one each morning. For the most part these sessions were operated on a strict schedule so as to balance the time between presentation and resulting discussion. This program control contributed to the effectiveness of the sessions, all of which were heavily attended (as high as 300 persons per session). In so far as possible papers were grouped on the program according to their subject matter and expected appeal.

One effort which undoubtedly contributed in an important way to the smooth and effective handling of the various technical sessions was the holding each morning, preceding the session, of a breakfast meeting presided over by the chairman of that day's session and attended by all persons involved in the presentation of papers for that session. At these informal conferences last minute details involving the coordination of presentation and discussion were worked out to mutual satisfaction, and any special contingencies taken care of, all to the benefit of the session itself. The technical program was under the direction of Prof. J. F. H. Douglas, whose committee comprised L. R. Mapes and H. E. Wulfing, of Chicago, Ill., E. Bennett of Madison, Wis., B. H. Clingerman of Minneapolis, Minn., G. E. Lewis of Ann Arbor, Mich., and S. H. Mortensen and G. G. Post of Milwaukee, Wis.

### Student Program

The student program, in addition to active student participation in all meeting activities, included a Monday morning executive session of the student activities committee under the chairmanship of Prof. C. C. Knipmeyer, student counselor for the Great Lakes District. At that session there was 100 per cent attendance of Student Branch chairmen from the sixteen Branches in the district. Each chairman gave a report covering the year's work of his branch, and also outlined plans and problems involved in future activities. An open forum discussion resulted in a highly desirable interchange of ideas.

The student technical session held Monday afternoon was attended by 225 Enrolled Students, comprising an excellent representation from each of the District's sixteen Branches. Ten excellent technical papers prepared by nineteen student authors were presented during the afternoon's session. Interest was so intense that all present remained throughout the entire afternoon for the presentation of the whole group of papers, maintaining the closest attention throughout the session. The 150 mimeographed copies of each of the ten papers that were available for distribution at the meeting failed to meet the demand. Papers presented included the following:

1. The Electron Tube in the Modern World, F. M. Deerhake, University of Illinois.
2. Opportunities in Home Lighting, D. W. Marchant, University of Iowa.
3. Low Voltage A-C. Distribution Networks, O. J. DeBever, Lewis Institute.
4. Magnetic Tests of Cold Rolled Steel, Grey Cast Iron and Chrome-Nickel Cast Iron at High Flux Densities, E. Halbach, H. Van-Pietersom, C. R. Dernbach, C. G. Post, C. R. Mikolic, M. J. Auchter, R. G. Klein, and H. A. Trimborn, Marquette University.
5. Distribution of Electricity for Lighting of Buildings, L. Zanoff, University of Michigan.
6. Resonance in a Non-Linear Circuit, R. T. Bozak, School of Engineering of Milwaukee.
7. An Experimental Study of Induction Motor Losses, E. S. Loye, and L. A. Rovelshy, University of Minnesota.
8. Television, an Invention in the Making, E. M. Purcell, Purdue University.
9. Dibutyl Phthalate as a Substitute for Transformer Oil, J. W. Niemi, and J. H. Montgomery, Rose Polytechnic Institute.
10. Rectilinear Graphs, H. E. Grant, University of Wisconsin.

Monday evening a special student dinner was served at the Marquette Union, followed by suitable brief addresses and a lively St. Patrick's celebration under the auspices of the local Student Branches. Prof. C. C. Knipmeyer in charge of student program, was ably assisted by E. W. Kane and V. M. Murray of Milwaukee.

### Entertainment Features

Active in supporting Milwaukee's reputation for hospitality, the various committees that promoted and handled the inspection trips, the women's activities, and the dinner-dance program provided those attending the meeting with more than they could do within the allotted time. These activities were well conceived and carefully and smoothly fitted into the general program for the Milwaukee meeting. Inspection trips, available each afternoon, embraced local industrial and municipal undertakings of a scope sufficiently wide to meet the desires of the most critical. Transportation was supplied by the local committee for trips *en masse* for the larger and more popular trips, and transportation for small parties wishing to make trips of a special character. This feature of the program was under the direction of W. F. Lent of Milwaukee, whose committee consisted of C. W. Kuhn, J. A. Potts, L. F. Reinhard, and R. C. Siegel, of Milwaukee.

Inspection trips included the plants of Allis-Chalmers Manufacturing Company, Falk Manufacturing Company, Cutler-Hammer Inc., Westinghouse Lamp Company, and the O. A. Smith Corporation; properties of The Milwaukee Electric Railway & Light Company and the Wisconsin Telephone Company; and the Milwaukee sewage disposal plant.

Activities planned for the women and carried out under the direction of Mrs. J. D. Ball of Milwaukee included shopping trips, sightseeing trips, and bridge and theater parties. Organized activities were supplemented by provisions to take care of special desires of smaller groups. Assisting Mrs. Ball were: Mrs. S. C. Fraser, Mrs. Fraser Jeffrey, Mrs. E. W. Kane, Mrs. F. A. Kartak, Mrs. V. M. Murray, Mrs. A. Simon, Mrs. C. H. Skinner, Mrs. R. B. Williamson, Mrs. S. H. Mortensen, and Mrs. E. W. Seeger.

A fitting climax to the entertainment side of the program was furnished by the informal dinner-dance held Tuesday evening under the direction of Prof. John D. Ball of Milwaukee, and his hard-working committee: F. A. Coffin, S. C. Fraser, J. A. Havlick, R. G. Lockell, O. W. A. Oetting, C. H. Skinner, Sam Snead, R. M. VanVleet, and C. T. Evans, all of Milwaukee and vicinity. Notably well done was the effort to make the dinner a true reflection of an old-time German festive affair in keeping with the best local custom, and those customs traditionally if not too accurately ascribed to Milwaukee. The German menu was more than most of those in attendance could decipher, but the result was voted a genuine success. Likewise the entertainment proved to be particularly well arranged, and was brought to a well conceived climax at the close of the dinner. The dinner entertainment features included the local and highly popular "Heidelberg Quartette," properly costumed and most popular when reflecting a German atmosphere; a "German street band"; two "sisters" in a Dutch wooden shoe dance; and subsequently in a song presentation Miss Kathleen Sauerwald, a contralto accompanied at the piano by her sister, whose beautiful presentations repeatedly "brought down the house" with round after round of enthusiastic applause. For the dancing subsequent to the meal, the "Electric Orchestra," electrical reproducing equipment functioning through a public address system set up for the occasion and operated under the engineering guidance of R. E. Deland and Sam Snead, admirably (and very economically) supplied selected dance numbers to supplement the efforts of "Heine's Band."

A registration exceeding expectations by 50 per cent was efficiently handled by J. U. Heuser and his committee: F. T. Coup, J. L. Defandorf, W. H. Fernholz, I. L. Illing, C. G. Matthews, and H. A. Bartlin. Mr. Heuser's committee was effectively assisted in registration work by a group of young women generously supplied by the Milwaukee Association of Commerce. The Pfister Hotel was exceptionally generous in making available without cost rooms and services for meeting purposes.

One of the features of the Milwaukee meeting was a policy of no registration fee either for members or students. The success of this policy, in spite of the heavy offering of inspection and entertainment activities, was made possible by the hard work of the finance committee under the direction of Fraser Jeffrey, of Milwaukee, and his committee: R. L. Dodd, P. B. Harwood, and H. L. Van Valkenburg, of Milwaukee; and K. A. Auty of Chicago, Ill. That the publicity efforts of R. R. Knoerr and his aid, J. H. Sobey, were effective was evidenced by the repeated attention given to the meeting by Milwaukee and other Wisconsin papers.

## Executive Committee Memorializes Leaders

Two long-active leaders in the affairs of the American Institute of Electrical Engineers, recently deceased, were memorialized by the executive committee of the Institute's board of directors at its regular meeting held at national headquarters March 9, 1932. Resolutions adopted giving official recognition to the valued services of former National Secretary F. L. Hutchinson are recorded in full on p. 227 of this issue; those recognizing the services of the late Dr. Harold Babbitt Smith, past-president of the Institute, follow:

WHEREAS: Through the death of Professor Harold B. Smith the American Institute of Electrical Engineers has lost one of its most active and influential members, a noted leader who had rendered valuable services as a member of many committees, a director, a vice-president, and as president,

WHEREAS: His keen interest in District, Section, and Branch activities and his success in encouraging their development contributed much to the growth and influence of the Institute,

WHEREAS: His vigorous leadership in electrical engineering education and research, his ability to correlate developments in theory and practise, his deep interest in the progress of his students and former students, as well as his quiet, persistent enthusiasm for the development of the entire electrical engineering field won the high respect of many friends, be it, therefore,

RESOLVED: That the executive committee on behalf of the membership hereby expresses its sense of the great loss which the Institute and the entire engineering profession have sustained, and be it further

RESOLVED: That these resolutions be entered in the minutes and that a copy be transmitted to members of his family.

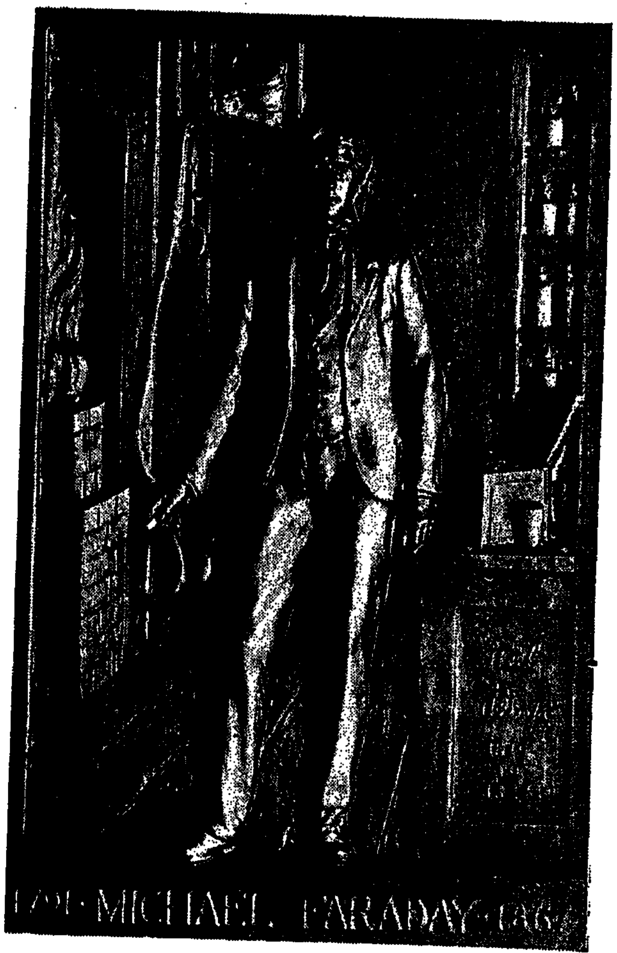
**American Welding Society to Meet in April.**—A tentative program has been announced for the annual meeting of the American Welding Society to be held in the Engineering Societies Building, 33 West 39th Street, New York, N. Y., April 27–29, 1932. Five technical sessions including 23 papers, covering a wide variety of subjects, have been scheduled. In addition there will be a business session and meetings of the board of directors, the structural steel welding committee, and the American Bureau of Welding. The eleventh annual dinner which will be arranged as a stag affair is scheduled for the evening of April 28.

## Faraday Plaque Given to the Institute

Sir Robert A. Hadfield, London, England, has presented to the Institute a bronze plaque of Michael Faraday, having as a background the workshop in which Faraday performed his experiments on steels and alloys. On the right is shown a box, labeled by Faraday, and in which were found 79 of his specimens of steel and alloy steel, while on the left is shown the famous "blast" furnace used by Faraday. The plaque has been accepted by the board of directors of the Institute.

It measures 13 x 8$^1/_2$ in., and is a replica of that prepared by F. J. Halnon, a sculpture of some note in London, and used as the basis for the frontispiece of a book "Faraday and His Metallurgical Researches" recently written by Sir Robert Hadfield. This book, having special reference to the development of alloy steel, has been prepared by a man who is himself not only a disciple of Faraday, but also a metallurgist through his numerous researches contributing much to the development of magnetic and other steels.

The story deals with the work of Michael Faraday during the period between 1819 and 1824 when he confined his investigations to the realm of metallurgy. This was his first research and led to others which he later made in chemistry and electricity. In addition to the historical matter in the book, much technical information is included, so that a careful study may be found to be of practical importance. Considerable research and investigation were undertaken in preparing the text, and the author has combined these results with the historical data in a volume most pleasing and interesting to read. The book, 329 pages in length and carefully illustrated, is published by Chapman and Hall, Ltd., London, England.



# Summarized Review of Some Winter Convention Discussions

PRINCIPAL discussions of winter convention papers are summarized herewith. The papers to which these discussions refer were abstracted in ELECTRICAL ENGINEERING for January 1932, p. 39–49 and February 1932, p. 130–2, excepting only the papers given more complete treatment in these same issues; additional articles based upon these papers are being presented in subsequent issues.

Only discussion submitted in writing in accordance with governing A.I.E.E. rules is summarized. Complete discussion together with all approved papers will be published in the TRANSACTIONS.

## Protective Devices

### A NEW HIGH SPEED DISTANCE RELAY

J. H. Neher (Philadelphia, Pa.) discussed this paper and pointed out that no assurance is offered that the relay will operate on a high-speed basis when three-phase flashovers of low arc impedance occur near the relay. He believed the problem could not be solved until there is developed a directional element which will give high-speed operation under this condition.

O. C. Traver (Philadelphia, Pa.) in his discussion of this subject remarked that the modified impedance relay described in the paper was a distinct step in advance over previous impedance relays. He agreed that, if it is to work selectively, the reactance relay must be provided with greater discriminating power than the impedance type. On the other hand he believed that the straight impedance type, and to a lesser extent the impedance-reactance relay, was apt to be too conservative and neglect its duty, so reactance would be the preferable function.

W. A. Hillebrand (Barberton, Ohio) inquired, in connection with the use of the series condenser as indicated in Fig. 6 of the paper, if there would be any inherent objection to using a bushing or other potential device instead of the series condenser to obtain the lead angle.

R. D. Evans (East Pittsburgh, Pa.) in his discussion summed up conditions which prevail on modern power systems. He explained that these conditions create a need for the modified impedance relay described in the paper. This device while still retaining its characteristic as an impedance relay minimizes the effects of fault resistance.

### OIL CIRCUIT BREAKERS

Philip Sporn (New York, N. Y.) reported that during the past year great improvement in breaker and system performance was obtained by the use of both the deion grid and oil blast explosion chamber breakers. Another point which he stressed was the inadequacy of the present standard duty cycle. In view of recent developments and tests, manufacturers were urged to offer users of oil circuit breakers a duty cycle which would be more consistent with actual power system operation.

J. Slepian (East Pittsburgh, Pa.) discussed "The Theory of Oil Blast Circuit Breakers" and disputed several of the principles. He explained the useful function of an arc by considering what would happen should it not form spontaneously when separating a pair of contacts in a power circuit. The hydromechanical principles also were analyzed as was some of the data; the discusser contended that some data given in the paper did not support the author's claims.

E. J. Poitras (Philadelphia, Pa.) answered several questions raised in discussion of this subject. He explained that the first group of tests was made where rates of rise of recovery voltage above 500 volts per microsec. were not available. They were not made with a view to completely filling in the graph and so no effort was made to obtain abnormally low oil velocities. When plotted in terms of recovery voltage rate and oil velocity, each parameter covering a reasonably wide range showed the excellent correlation of these parameters with success or failure to clear the circuit at the first current zero. He further explained that while it would have been desirable to make tests at all oil velocities and recovery rates and for all different generator voltages, such were not deemed advisable because, in circuit interruption, recovery voltage rate rather than nominal voltage is unquestionably predominant, and the making of many tests is expensive.

W. K. Rankin (Philadelphia, Pa.) in his remarks referred to the theory of deionization by turbulence as compared with the closing of the arc path at current zero by a fluid dielectric. He believes that the former theory bore some weight, even though in the case of an arc drawn to considerable length in a tank of oil other theories have been proposed. However, when considering a maximum of 1 in. contact separation, and recovery voltage rates of rise from 135 to 800 volts per microsec. across the contacts, tests have proved that the gaseous dielectric would not prevent breakdown; therefore he concludes that oil which does have sufficient dielectric strength is inserted between the contacts.

F. H. Stoppelman read a discussion on this subject prepared by C. L. Fortescue (East Pittsburgh, Pa.) which referred to early experimental work. The results indicated that something besides length was required to quench an arc. In fact, as shown in the papers by Messrs. Browne, Van Sickle, and Leeds, the requirement now is a turbulent gas stream across the path of the arc. He believed data on the oil blast principle would be explained just as well by the fact that the gas formation and its turbulency are functions of the velocity by which the oil is introduced into the ionized path between electrodes.

J. B. MacNeill (East Pittsburgh, Pa.) in his discussion of circuit breakers drew attention to the general improvement made in these interrupting devices and the reduction of the hazards which result from the use of oil in these devices. He believes the oil blast device operating on one end of the arc to be most effective for low voltages; however, for high voltages he questions its ability to produce effective results, and advocates the deion grid principle of interposing successive increments of arc rupturing ability as the arc is lengthened by the gases which have formed passing transversely across the full arc length.

T. E. Browne, Jr. (East Pittsburgh, Pa.) discussed this subject, in his conclusion submitting three reasons why it was impossible for him to agree with Mr. Prince's conclusions. One of these reasons was that as yet no detailed picture capable of withstanding critical analysis has been presented of the mechanics by which the oil film may be formed.

### EXTINCTION OF A-C. ARCS

R. C. Van Sickle discussed this subject and pointed out certain differences between the functioning of the experimental structure described by Mr. Browne and the deion grids, which differences should be realized when comparing results as they might explain why the recovery voltage gradients of deion grids are higher.

J. J. Torok (East Pittsburgh, Pa.) discussed this subject and described an experiment on extinguishing arcs in fiber tubes wherein droplets in the tube materially increased the surface on which ions could be collected. He found that the author's treatment of the expulsion fuse substantiated the theory of the turbulent gases.

W. A. Hillebrand (Barberton, Ohio) discussed this subject also and briefly described the Poulsen radio arc transmitter. He believes that the curves presented by Mr. Browne confirm earlier experience with this transmitter. He also offered as a possible contributing cause for the difference between the curves of Fig. 6 for oxygen and nitrogen, the fact that free electrons can exist in an atmosphere of nitrogen but not in an atmosphere of oxygen.

## Instruments and Measurements

### A POWER FACTOR BRIDGE OF HIGH SENSITIVITY

Perry A. Borden (Waterbury, Conn.) discussed this subject and described a method of balancing out induced voltages in the galvanometer coil by the use of a neutral inductance in the field circuit; this would appear to remove one of the objectionable features of the electrodynamic galvanometer.

J. C. Balsbaugh (Cambridge A, Mass.) discussed this subject and told of a modified Schering bridge using an amplifier in the detector circuit offering a precision in power factor measurement of $10^{-6}$, this modified form having been constructed at the Massachusetts Institute of Technology. When all the factors affecting the power factor precision of the bridge have been fully investigated, it is planned to make formal publication of this research. In conclusion, the discusser pointed out that there were no calculations or tests giving the sensitivity or precision of the bridge described in the paper.

Leo J. Berberich (Paulsboro, N. J.) discussed the high accuracy of power factor measurements possible when using a bridge of the type described in the paper. He gave data which showed the excellent agreement found between the computed power factor of the standard and the power factor as measured by the bridges of the type described by Doctor Kouwenhoven. It evidenced also close agreement between the two bridges used at the Johns Hopkins University.

S. K. Waldorf (Baltimore, Md.) analyzed several cases mentioned in this paper, commenting upon the net effect of a reduction of specimen size, high humidity conditions, and double shielding on the transformer used in the galvanometer circuit. He also warned those who have occasion to build small high voltage air capacitors against the use of small plate dimensions, and a spacing of not less than five millimeters was suggested.

One of the points considered by R. P. Siskind (Cambridge, Mass.) in his discussion of this paper was the possible effect upon the accuracy of the bridge from the presence of harmonics. He explained that when a potential sufficiently high was applied to the test specimen it would cause ionization producing third and other harmonics. It was believed that these might cause some small error to exist in the bridge.

### INSTRUMENT SPRINGS

A. B. Smith (Chicago, Ill.) discussed the use of the grid glow micrometer mentioned in the paper. He told of having previously compared the use for detection purposes of a 2-watt, 110-volt neon lamp with a radio headset. The comparison revealed advantages in the use of the receiver, such as sensitivity when the resistance was greater than 59 megohms. Also with the use of a receiver for detection, the eye is left free for other observations.

J. R. Townsend (New York) discussed the means of stabilizing instrument springs and referred to the work of Sayre, Dalby, Scott, and Abbott. He believes the method of heating above the service temperature as suggested by Messrs. Carson and MacGahan, to be a good one.

### AN AUTOMATIC OSCILLOGRAPH

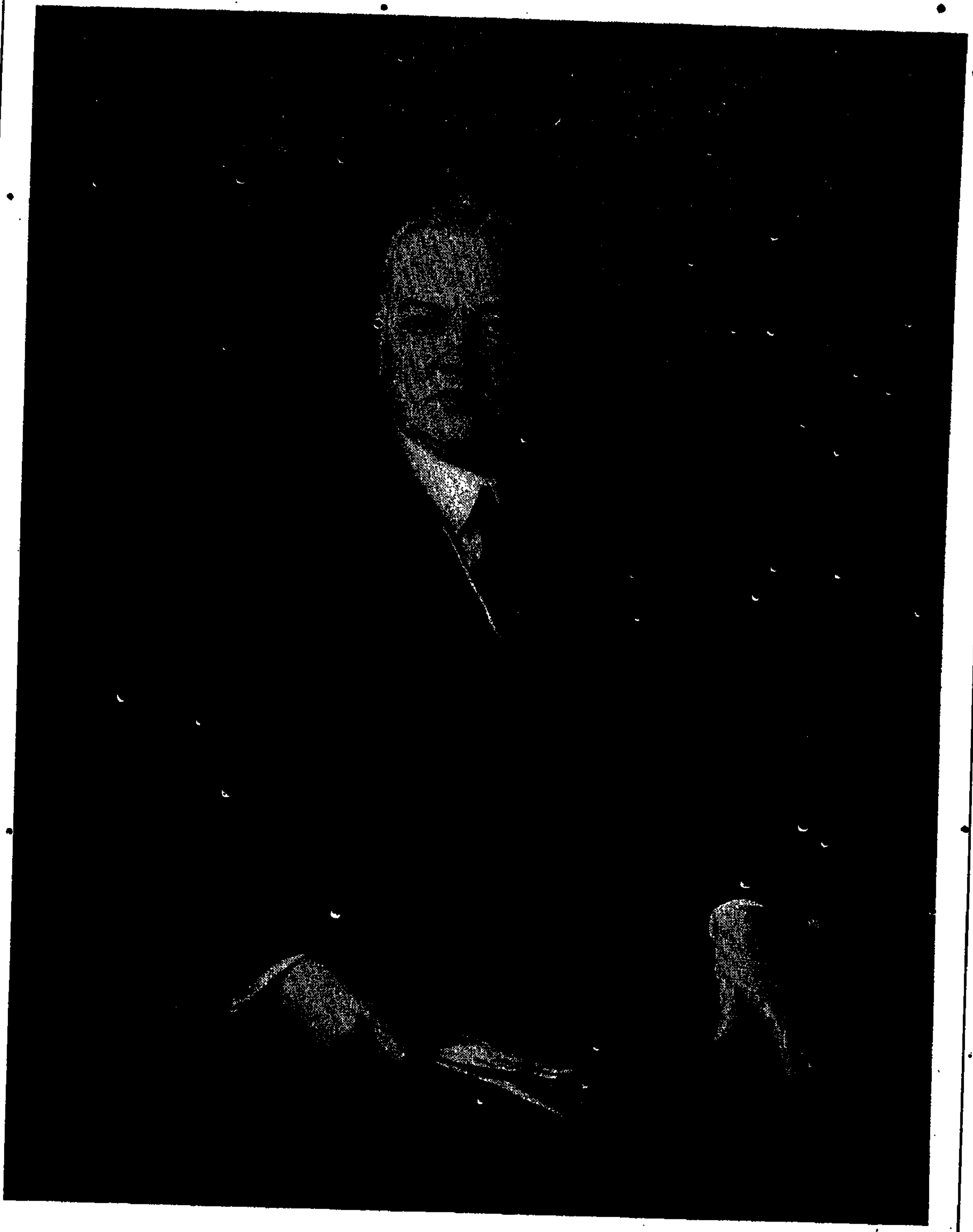
Wm. G. Walker (Philadelphia, Pa.) told of experience at Plymouth Meeting Substation with a development model and later a commercial model of the oscillograph described in the paper. Several suggestions advanced by the men maintaining the development model were incorporated in the commercial model. Out of 63 operations recorded during an interval of 160 days, no records were lost through failure of the instrument to function.

### THE PHOTOELECTRIC RECORDER

P. E. Quiss (Lynn, Mass.) discussed this subject and emphasized the sensitivity and quick starting features of this apparatus which enable it to record values heretofore measured only by the use of indicating instruments.

C. W. Mayott (Hartford, Conn.) explained that the photoelectric recorder had been installed in the load supervising office at Hartford. It has been in service for

## The Engineer President



WITH SIMPLE CEREMONY this de Laszlo painting of Herbert Hoover—Honorary Member of the civil, mining, mechanical, and electrical engineering societies and past-president of the American Institute of Mining and Metallurgical Engineers—was unveiled February 15, 1932, before a meeting of the United Engineering Trustees, Inc., held in the Engineering Societies Building at 25–33 West 39th Street, New York, N. Y. To this meeting were invited the presidents, vice-presidents, secretaries, and boards of directors of the four national engineering societies, and a few other especially prominent engineers and organization representatives. As chairman of the Hoover Medal Board of Award, representing the four engineering societies, Dr. Gano Dunn, past-president of the Institute, delivered the portrait to H. A. Kidder, Fellow of the Institute and president of the United Engineering Trustees, the organization which will be the official custodian of the portrait.

President Hoover kindly sat for the painting during Christmas week, 1931, in response to a request made jointly by the four national engineering societies. The portrait was arranged for at that time in order to take advantage of the presence in this country of the internationally known artist, Philip A. de Laszlo of London, England. The portrait of President Hoover, mounted in a valuable frame contributed by the artist, now is the joint property of the four engineering societies and is to be hung prominently on the east wall of the reading room of the Engineering Societies Library "where it can be seen by engineers and the public alike, and where it may constantly stir to pride and emulation the members of the engineering profession."

approximately a year and a half. During this time the only replacement required was the light source bulb. Frequency records were obtained in such detail as to be beyond the requirements of any present operating demands.

H. A. Rolnick (Philadelphia, Pa.) inquired regarding the smallest angular motion of the indicating element to which the recorder would respond, and whether or not it was dependent on the electrical circuit, the optical system, or both.

## Distribution Circuit Lightning Protection

Harold C. Dean (New York, N. Y.) expressed belief that the most important contribution made to the industry by the papers in this symposium was the proof offered that lightning arrester ground leads should be connected to the secondary neutral where the latter is adequately grounded; he advocated also the grounding of transformer cases to the secondary neutral. It was explained that those in the New York Edison Company have the philosophy that a known hazard is to be preferred to an unknown hazard, and they have adopted as a standard the grounding of all transformer cases.

A. H. Schirmer (New York, N. Y.) explained that the results obtained from Bell system tests indicated that for transformer protection an arrester should be placed between the primary and secondary. The arrester should have a current limiting element so designed that the voltage across the transformer windings would be held to a value slightly below the impulse strength of the transformer. This would hold to the lowest practical value the lightning voltage on the secondary caused by a surge on the primary, and no power voltages of considerable magnitude would appear between the secondary circuit and ground.

F. W. Peek (Pittsfield, Mass.) suggested that with an object to devising lightning tests the proper technical committees of the Institute should review present methods of testing. These tests were suggested as a supplement to the present tests and not to supersede them. This suggestion for consideration was made after years of experience with lightning tests on transformers in an effort to devise lightning proof transformers and also for making lightning tests on commercial transformers. These facts were mentioned to show that lightning tests are entirely practicable.

A. E. Silver (New York, N. Y.) called attention to the change in trend toward the objective of lightning protection. He explained that in the past, attention to the subject of lightning on distribution circuits seemed to have centered on the distribution transformer and what could be done to protect it rather than upon lightning effects on service. He commended the authors of the paper on the Philadelphia Electric system for moving the main objective of their studies from the distribution transformer to its effects upon service.

C. L. Fortescue (East Pittsburgh, Pa.) analyzed the proposed connection of the lightning arrester ground lead to the secondary neutral as advocated in the papers. He believes that the proposed connection assured much better protection to the transformer than the old connection, without any increase in hazard to the customer. As compared with unprotected transformers, he believes the connection gives much better protection to the customer because it prevents high voltage from entering into customers' circuits. Also the hazard of fire or personal injury is much greater from high voltage power current than it would be from any surge likely to pass through into customers' circuits.

A. S. Brookes (Newark, N. J.) discussed several details in the paper by Messrs. Harding and Sprague. He believes the analysis might have been made much more valuable by a more detailed consideration of the circuit distances involved, and if more data on the surge current and the circuit details were given. He felt that the interconnection of the primary arrester ground and the secondary neutral had more merits than the results given in the paper indicate.

J. K. Hodnette (Sharon, Pa.) discussed this subject from the standpoint of distribution transformer design. He described a self-contained, self-protecting transformer with gaps inserted between the high-voltage and low-voltage leads, and the ground, to enable the transformer to withstand many surges without injury to the insulation. This surge-proof transformer has withstood tests approximating service conditions as nearly as possible, with surges of various magnitudes up to 1,500,000 volts impressed upon the excited supply lines. In every case the transformer was protected and normal voltage was restored without causing so much as a flicker in lamps supplied from secondary leads of the transformer.

H. V. Putman (Sharon, Pa.) pointed out limitations of the proposed interconnection which he believed ought to be given careful consideration. He explained why he believed the straight interconnection not well adapted to installations having a low voltage neutral ground connection of high resistance, nor to installations without grounds on the service lines; nor yet to installations with grounded transformer tanks or to three phase installations.

M. G. Lloyd (Washington, D. C.) summed up results and conclusions of the several papers on lightning protection. He explained that the committee on protection against lightning of the National Fire Protection Association for some time has had under consideration the advisability of using lightning arresters on overhead secondary circuits where they enter buildings. This would seem necessary only in rural districts and where wires enter the building as separate open wires. Since it would be necessary to interrupt follow current at only 120 volts, an arrester of cheap construction would suffice.

J. J. Torok (East Pittsburgh, Pa.) discussed and carefully analyzed benefits to be obtained from the standpoint of personal hazard to the customer in the proposed interconnection of the lightning arrester ground lead and the neutral of the secondary. He explained that without the interconnection a power arc established across the transformer terminals would raise the secondary leads to primary potential. This condition would last as long as the arc was maintained, probably for several seconds. With the interconnection the action of the lightning arrester would come in at a voltage lower than that at which flashover of the transformer bushings would occur. Thus the arrester would prevent 60-cycle power follow or would limit it at most to a half-cycle duration. The power follow is more dangerous to life than the impulse voltages which, although of much higher values, are of short duration.

Edward Beck (East Pittsburgh, Pa.) described tests performed on a circuit set up in the laboratory to simulate an energized 2,300-volt circuit feeding a 110/220-volt house circuit with various household appliances attached. The transformer was protected with a 3,000-volt auto-valve arrester with the proposed interconnection employed. Surges were impressed on the primary of magnitudes sufficient to discharge 800, 1,600, and 3,000 amperes through the primary arresters, and cathode ray oscillograms were made of voltages occurring on the secondary system. The ground resistance was varied from zero to 57 ohms. The results revealed that the voltages to ground of the phase wires and the neutral wire were very nearly alike except for the first instant. Well over 1,000 surges were impressed and only three interruptions to the customers' service occurred. These consisted of blown fuses only. From the results obtained it was concluded that the interconnection did not impair conditions in the secondary system.

K. B. McEachron (Pittsfield, Mass.) discussed the proposed interconnection and described a modified form of conventional lightning arrester for installation within the space available inside the transformer tank. The arrester operation is in no way different than when applied externally, having the same factors of safety and the same reliability. This construction would have the advantages of reducing both installation costs and congestion on poles. Reasons, the result of experience, were given showing why gaps were unsuitable.

## General Circuit Theory

R. D. Evans (East Pittsburgh, Pa.) briefly reviewed some of the developments which have taken place in general circuit theory during the past 20 years. He told of any early problem in power system networks which was in connection with the supply systems for a-c. railways. This he explained was followed by a very important step in network theory; namely, the introduction of the method of symmetrical components by Doctor Fortescue, to make possible the solution of unbalanced power system networks. He further explained that recently the stability problem has made it necessary to develop new forms of circuit constants in order to facilitate the solution of general networks, taking into account not only distributed constants but their combination with lump constants. In conclusion, he pointed out that the most striking development within the last few years was the introduction of the a-c. calculating board. This has made possible the solution of many problems in a more complete manner and in less time than heretofore required.

### EQUIVALENT CIRCUITS

J. W. Butler (Schenectady, N. Y.) illustrated with examples the usefulness of the

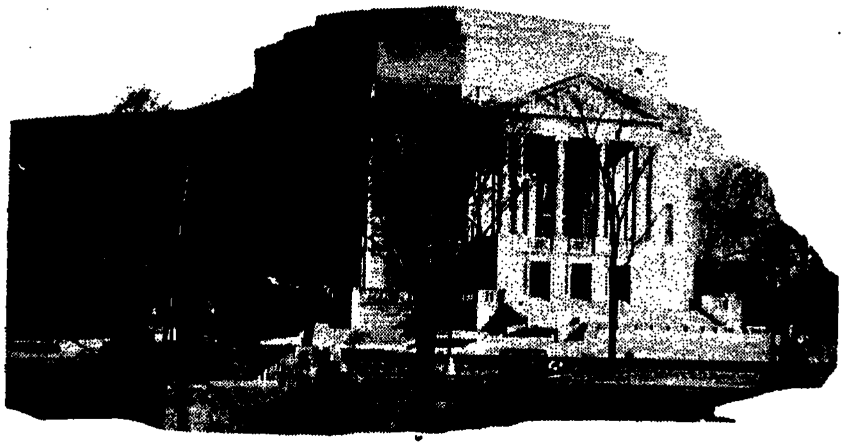
(*Continued on p. 276*)

# Cleveland Cordially Invites You

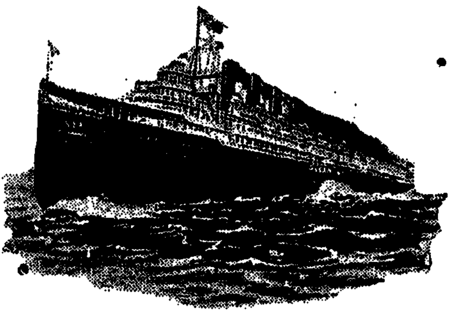
## To the Annual Summer Convention, June 20-24, 1932

The committees are working hard to assure you a profitable and entertaining visit. No registration fee.

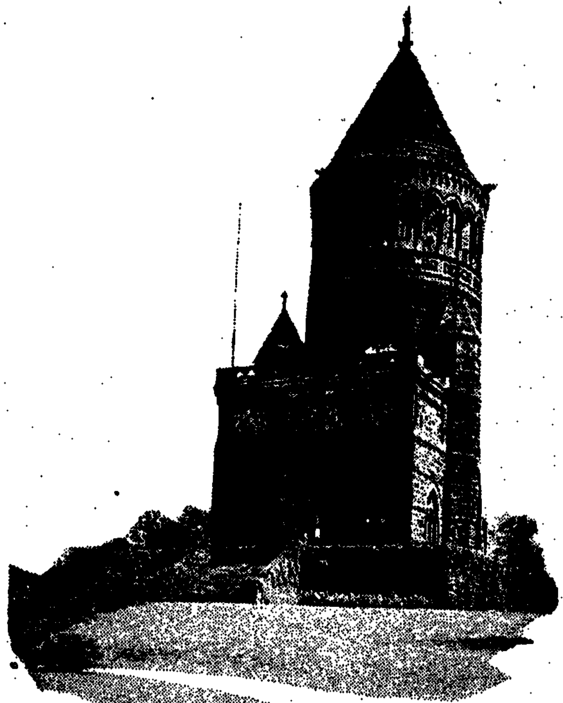
Cleveland Museum of Art, inspection of which is included in the ladies' entertainment program for Monday, June 20, 1932



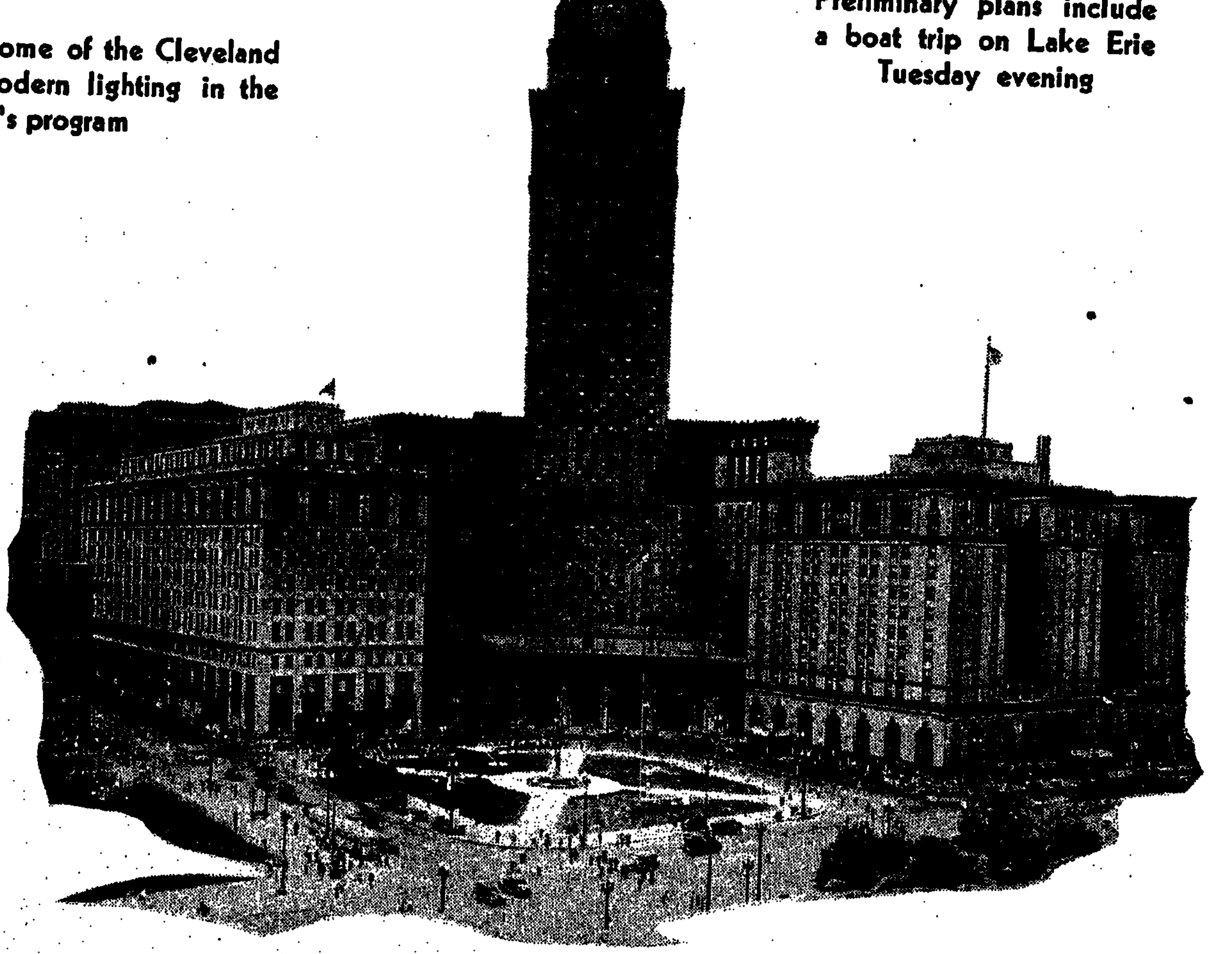
Inspection of Severance Hall, the new home of the Cleveland Symphony Orchestra, with the most modern lighting in the country, is included in Friday's program



Preliminary plans include a boat trip on Lake Erie Tuesday evening

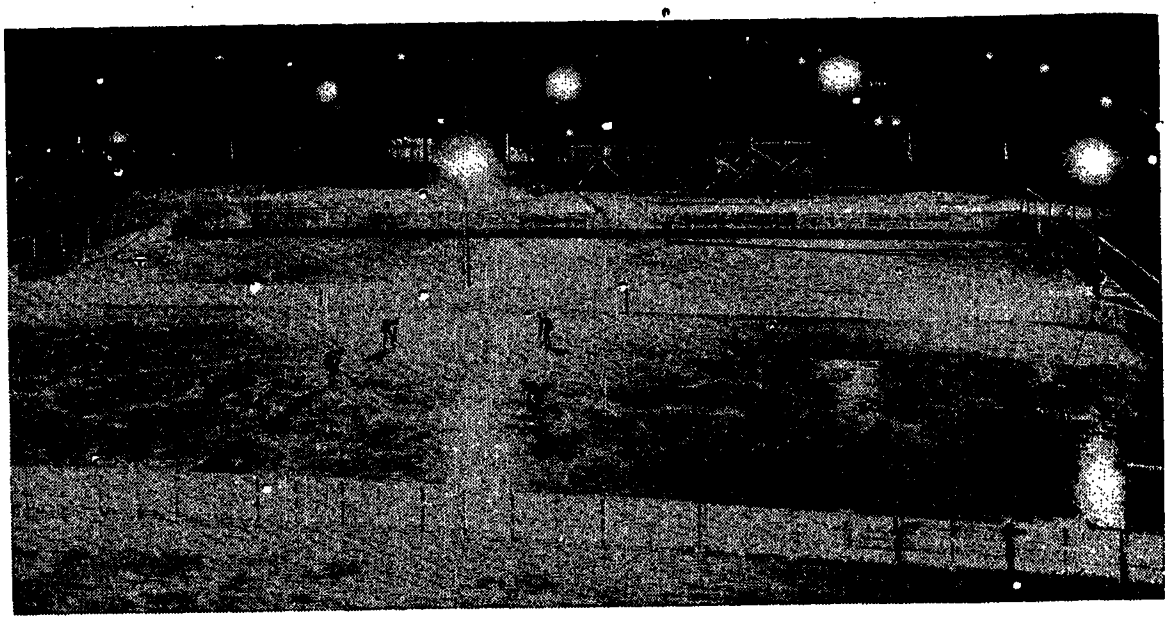


Garfield's Tomb, one of the many points of interest in Cleveland



The Cleveland Union Terminal group on Public Square, including Cleveland Hotel (at the extreme right) which is to be the convention headquarters

## Floodlighting for Hockey Rinks at Lake Placid



THE TWO hockey rinks and the adjacent ice skating speed tracks for the Olympic stadium at Lake Placid, N. Y., are floodlighted by the well diffused rays of 29 General Electric Company floodlights. Several of the hockey matches and races of the Olympic games, February 4–13, 1932, thus were successfully conducted at night. A total of 43 kw. is required to illuminate the 245 x 628 ft. of ice surface.

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(*Winter discussion continued from p. 274*)

method which Mr. Starr had developed in part III of his paper, for setting up several simplified equivalent circuits. One example illustrated the simplicity of setting up an equivalent single line circuit to represent a four winding transformer.

Edith Clarke (Schenectady, N. Y.) explained that the paper on this subject presented the general circuit equations for networks in systematic and concise form, with methods for measuring and calculating the characteristic coefficients. She felt that Mr. Starr had made a valuable contribution to their solution. She believed also that one of the simplifications which will be found of advantage, where an a-c. calculating table is not available or when greater accuracy is required than can be secured by its use, is that of placing the self-impedance at the terminals and not in the mesh of the equivalent circuits.

R. G. Lorraine (Schenectady, N. Y.) discussed this subject and believes the paper, with its presentation of the general principles upon which the development of specific equivalent circuits depends, to be a welcome addition to the literature on equivalent circuits. One of the points which he emphasized was that even though the author's equivalent circuits contain pure reactance branches means are available to represent them adequately on the a-c. calculating table.

W. A. Lewis (East Pittsburgh, Pa.) found several of the equivalent circuits presented by the author to be both new and interesting. He believes a slight error in statement appeared on page 5 and again in the footnote on page 9, where it was stated that the mutual impedance between lines is purely reactive. It was explained that the mutual impedance is due not only to inductive coupling but also to the common use by all circuits of the earth and ground wires, if present. This resistance often may be as large in proportion to the mutual impedance as the combined resistances of earth circuit and conductor is to the zero phase sequence self-impedance. Therefore it seldom can be neglected unless the accuracy required permits neglecting all resistances.

George W. Hampe (Chicago, Ill.) in his discussion of this subject referred to previous work and the principles stated in 1911 by Mr. G. A. Campbell. He explained that the complete or lattice mesh, of which Fig. 1(d) and Fig. 3(b) of the paper are examples, could be handled more readily if admittances instead of impedances were used to express its links. A simple process for finding the branches of the complete mesh equivalent to the general concealed network was given by Mr. Campbell. The discusser gave an example of its derivation without the use of determinants.

### TRANSIENT OSCILLATIONS OF MUTUALLY COUPLED CIRCUITS

H. L. Rorden (Pittsfield, Mass.) discussed this subject and illustrated several points of interest with specific calculations based on Mr. Bewley's derivations. A table of calculated transients was given listing the essential terms for three space harmonics as calculated for the given constants, and conclusions drawn from these calculations were enumerated. An analogy also was given by comparing the general distributed circuit with the lumped constant circuit which exhibited similar characteristics.

## Drives for Power Station Auxiliaries

A. H. Kehoe (New York, N. Y.) told of experiences in the New York Edison system with both steam and electric drives for power station auxiliaries; continuity of station output has been obtained with either steam or electric auxiliary drive. This has been accomplished by supplying steam from headers which are provided with sectionalizing valves and fed from two or more sources, and each essential auxiliary motor circuit has its supply available from several sources. This system has found some saving in installed first cost of auxiliaries with electric drive instead of steam, especially where the simpler types of motors are adaptable.

I. E. Moultrop (Boston, Mass.) believed the papers presented on this problem were valuable and timely in bringing to the attention of the industry the need for more suitable and more economical drives. He predicted that auxiliary power requirements of the stations built in the future probably will be considerably in excess of those past or present. For high pressure boiler feed pumps he favored the use of turbine drive because it permits the best pump design, and the usual horsepower requirements permit a highly economical design. He called attention to the lack of satisfactory variable-speed a-c. motors, and many other interesting points were brought out in his discussion of this subject.

Francis Hodgkinson (Lester, Pa.) emphasized the importance of reliability of the drives for the essential power station auxiliaries. He discussed the trend in modern power plant design and in particular, stage bleeding for preheating, which no longer makes the exhaust heat from steam auxiliaries essential. His considerations in addition to the statements in the papers led generally to a preference for the electric drive for all essential auxiliaries except boiler feed pumps and fans.

H. M. Cushing (Buffalo, N. Y.) believed the trend of the development was clearly depicted in the three papers by Messrs. Hollister, Dryer, and Smith. However, he believed Mr. Dryer in handling the subject of steam driven auxiliaries had made a very favorable case for the electric drive. He was in agreement with all conclusions in this paper except Nos. 1, 5, and 8. It was explained that the Huntley Station started with a preponderance of steam driven auxiliaries. However, its engineers and operating men are now so convinced of the superiority of electric drive that in the new 60-cycle steam plant, known as Huntley Station No. 2, it was used exclusively for driving the auxiliaries. He explained further that the general use of electric drive had been delayed by a number of causes and pointed out many important features of the electrical installation for electric drives.

F. C. Hanker (East Pittsburgh, Pa.) reviewed the requirement for electric auxiliary drives and carefully analyzed the characteristics of the available types of apparatus. He felt that a great deal of the criticism of electric drive was due undoubtedly to the effort to apply motors and control developed for industrial uses to the more rigorous duties imposed by central station conditions. It was believed that the trend toward the unit system of operation should permit simplification of both the power supply and the auxiliary drive. Complications should be avoided in the sources of supply; this would simplify the control for the auxiliaries as well as minimize the duplication of auxiliaries, as is frequently done in practise.

Robert Baker (New York, N. Y.) discussed the financial side of this question. He believed that comparisons between steam and electric drives for auxiliaries should be made on the basis of between 30 and 40 per cent capacity factor instead of maximum load conditions, as described in the paper on electric drives. A comparison on this basis would represent more nearly the actual operating conditions and would probably show a reduced saving. He pointed out that no figures were given as to the cost of the steam driven equipment required for a station using steam driven auxiliaries and that comparisons could be made up only on the basis of fuel cost. It was explained that comparisons of this nature gave only half the picture as an analysis of the over-all operating costs of the average plant shows that the cost of fixed charges is approximately equal to the fuel cost.

Philip Sporn (New York, N. Y.) believes the aim in auxiliary layouts for future power plants should be toward further simplification of the power supply and control equipment. He believes the merits of systems were now fairly well recognized so that further standardization and simplification could take place. The need for a simple, sturdy, variable speed a-c. drive, improved insulation, and consideration of the use of higher voltage motors, were some other interesting points brought out in this discussion.

S. M. Dean (Detroit, Mich.) believes that the papers give a good summary of the two situations so far as the auxiliaries themselves were concerned. However, he would like to have seen somewhat more complete cost data. It was also pointed out that the possibilities of d-c. drives should not be overlooked. When account is taken of the extent to which the station rating is reduced (some 5 per cent) the smoothness and ease of operation, the absence of serious short-circuit problems, etc., it does not compare unfavorably with other methods.

F. M. Stoddard (Cincinnati, Ohio) briefly described auxiliary installations at the Columbia power station. Power for the essential auxiliaries is supplied from shaft generators connected to each main turbine unit. The non-essential auxiliaries are supplied from transformers connected to the main bus, and in six years of operation there has been no trouble with the auxiliary system from loss of auxiliary power or fluctuation of bus voltage caused by external faults.

F. H. Hollister (Chicago, Ill.) in his discussion on this subject showed data on several desirable features of the Rossman drive which has been in successful operation for the past year, driving fans at the Powerton station.

## Symposium on Stability

### STANDARD DECREMENT CURVES

R. G. Lorraine (Schenectady, N. Y.) discussed this subject and analyzed the development and use of several of the curves presented in the paper. An example illustrating their use was given and further inspection of them showed that more confidence could be placed in the use of these curves than one would suppose from an inspection of the assumptions made in their derivation.

### DECREMENT CURVES FOR SPECIFIC SYSTEMS

H. B. Dwight (Cambridge, Mass.) discussed this paper with particular reference to a method for calculating sustained short-circuit currents using Potier reactance. He explained that for this calculation the value of armature ampere-turns at rated current is also required, and this may be obtained from the Potier triangle. A certain amount of zero power-factor armature current may be assumed and the excitation calculated using Potier reactance and armature ampere-turns. It was further explained that since the excitation usually is known, the calculation must be repeated with adjusted values of armature current until the resulting excitation has the correct value. This process seems necessary, and does not make the calculation unduly long.

### PROPOSED DEFINITIONS OF POWER SYSTEM TERMS

V. J. Cissna (New York, N. Y.) explained the preference for the convention of leading reactive power as positive, particularly on account of the power-circle diagram. This he illustrated with a figure. It was believed that in considering leading reactive power as negative the convention of the power-circle diagram had been troublesome to many engineers in that the conventional rotation of voltage vectors had been violated.

C. L. Dawes (Cambridge, Mass.) commented on the committee's definition of lagging reactive power in terms of the current delivered by an over-excited synchronous generator. He believes this to be an indirect and unnecessary method of defining reactive power and also that it is confusing to those who do not have immediately in mind the excitation characteristics of synchronous apparatus. Such reactive volt amperes he believes could have been much more explicity defined as the reactive volt amperes taken by an inductive reactance, and this would be easily understood by everyone familiar with alternating currents.

C. F. Wagner (East Pittsburgh, Pa.) also discussed this question as to whether or not inductive reactive power should be plotted as a positive or as a negative quantity in power circle diagrams. He gave a list of references to publications in which inductive reactive power is considered positive and also a list in which it is considered negative. These references dated over a period from 1910 to 1929, twenty-three authors considering inductive reactive power as positive while sixteen considered it as negative. In addition, authors such as Doctor Kennelly, Professor Jackson, and Doctor Fortescue, also preferred the use of the positive value. Therefore, the discusser believes that the inductive reactive power as a positive quantity should be adopted as the convention.

Edith Clarke (Schenectady, N. Y.) explained that she was in agreement with the proposal to consider leading reactive power positive and lagging reactive power negative. It was explained why voltage is chosen as the reference vector in dealing with network systems; the currents in the branches of the network then give a good indication of both active and reactive power flow. This correspondence of power and current was believed to be of sufficient importance to justify the proposed convention for active and reactive power.

A. E. Kennelly (Cambridge, Mass.) told of the work done by the International Electrotechnical Commission and analyzed considerations of the question as to whether reactive power should be represented by $P + jQ$ or $P - jQ$ vector voltamperes. He believes the subject committee here should transmit a recommendation to the A.I.E.E. standards committee as to the choice of vector direction so that the standards committee may be able to take early appropriate action with a view to renewing international proposals. If the reasons given for the final choice are cogent, he believes they would be likely to meet with indorsement from our engineering fraternities in other parts of the world.

L. A. Kilgore (East Pittsburgh, Pa.) discussed section 4 of this report covering the definition of synchronous machine constants with particular reference to the effects of saturation. He believes the report does not offer any simple method of dealing with the effects of saturation but leaves its degree indefinite. This he thinks might be confusing when using the constants in practical calculations for it appears we must have not only a large number of constants but different values for various conditions. It also will be necessary to state the degree of saturation every time a value of the constant is specified. He recommends from the conclusions of previous work, a definite and relatively simple means of dealing with saturation.

S. L. Henderson (East Pittsburgh, Pa.) believes the report to be a valuable piece of work. He suggests that a statement would be helpful in covering the particular machine constants to be used most often in the ordinary study of system performance. For example, values of transient, substransient synchronous, and negative and zero sequence reactances for the direct axis, together with the short-circuit ratio and the short-circuit time constant, are sufficient for the usual practical case.

### GENERALIZED STABILITY SOLUTION FOR METROPOLITAN TYPE SYSTEMS

R. D. Evans (East Pittsburgh, Pa.) called attention to the value of the generalized methods given in this paper. He explained that the general stability curves given in this paper may be used in a manner similar to that of the paper "Standard Decrement Curves" presented earlier in the session. It was predicted that the use of these curves together with previous curves developed for long distance straightaway transmission will lead to the development of similar methods for the remaining types of systems so that eventually shortcut methods will be available for all types of systems.

Another discussion by S. B. Crary (Schenectady, N. Y.) brought out that any generalization or simplification of a problem which comprises as many factors as a transient stability study, must require numerous assumptions and these limit the field of application. Therefore he believed that care must be used in applying the curves of Figs. 1 and 2 to systems that do not conform to the assumptions set forth.

S. H. Wright (Buffalo, N. Y.) explained that when applying the curves presented in the paper cases may frequently arise where conditions of the system being studied are met by the conditions assumed in preparing the curves except in one respect, making it desirable to consider the inertia constant as an additional "index factor." This was illustrated by an example.

### ELECTRICAL STABILITY OF CONOWINGO HYDROELECTRIC STATION

R. M. Spurck (Philadelphia, Pa.) discussed the last paper to be presented in this session. He believed the authors presented an excellent and complete paper on the analysis and solution of stability problems which occurred in connection with the operation of this station, both before and after the application of high-speed clearing equipment to the system. It was brought out that the correction of stability problems by high-speed circuit clearing also brings with it many other benefits, a few of which are reduced area of disturbance on the system during faults, reduction in voltage dips, and apparatus that requires less maintenance.

## Research

### RADIO INTERFERENCE FROM INSULATOR CORONA

J. W. Upp, Jr. (Baltimore, Md.), discussed this subject and he believes that over a period of years, insulator manufacturers interested in radio interference investigations have found modern insulators to be minor offenders. Insulators, he thinks, are further along the path of development of radio interference relief than most of the other factors involved in the manufacture, transmission, and consumption of electrical energy.

W. A. Hillebrand (Barberton, Ohio) inquired if the author of this paper considered his set-up suitable for a standardized test set, if he had any changes to recommend, and if, in his opinion, it had been described with sufficient accuracy in his papers to permit of its being accurately reproduced.

S. K. Waldorf (Baltimore, Md.) discussed several means for corona detection, one of which consisted of employing an audible corona detector having one or two stages of audio frequency amplification designed to accentuate frequencies greater than approximately 500 or 1,000 cycles per sec., and having a radio headset or loud speaker in the output. With this type of detector, even the presence of a small amount of corona is accompanied by a loud buzzing sound in the telephone or loud speaker. He also explained that it may be desirable in some cases to connect the input resistance of the corona detector in the grounding circuit of the insulator suspension or pin.

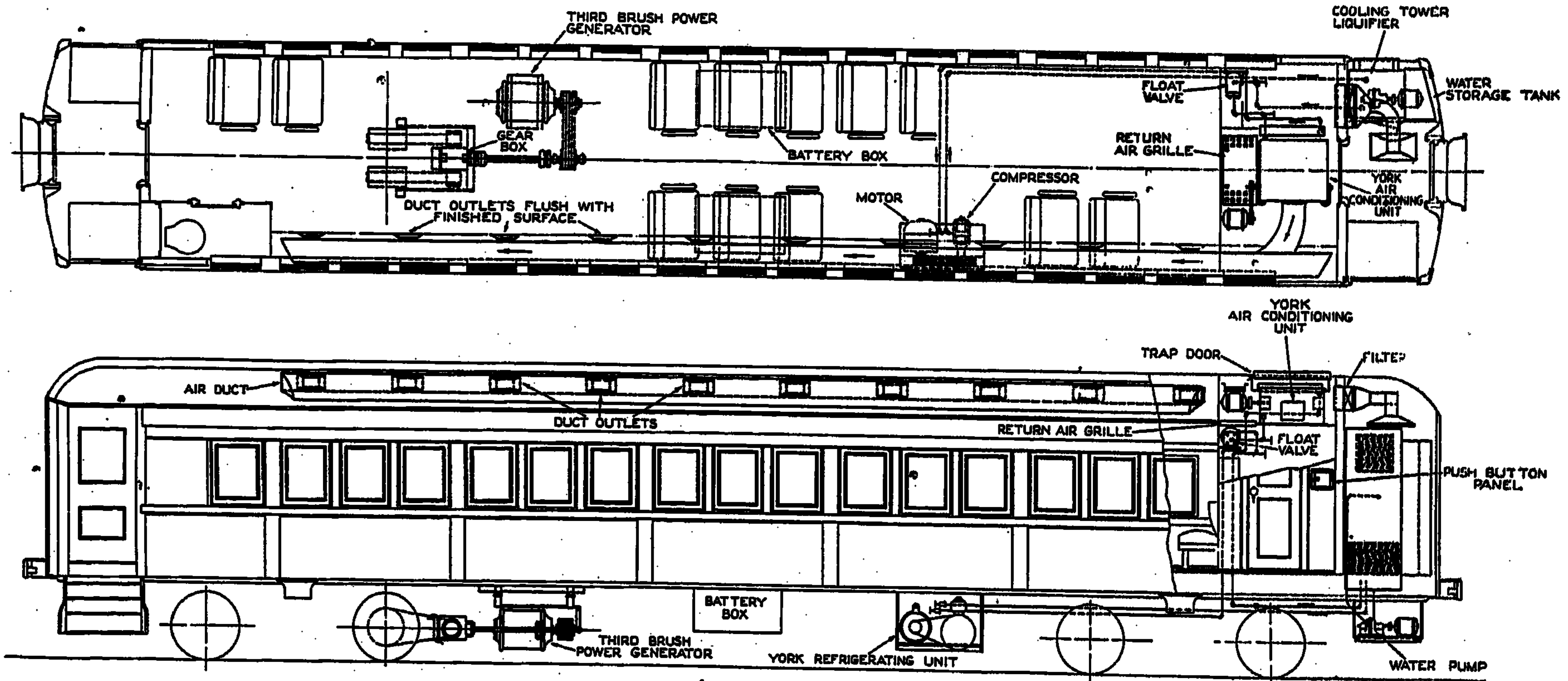
J. B. Whitehead (Baltimore, Md.) discussed the experimental method used in the paper with reference to balancing out the charging current of the high voltage circuit, the adjustment being made before corona forms. He explained that it is well known, however, that the presence of corona, owing to space charge formation, introduces important changes in the value of the geometric capacitance. It was believed that this fact might explain some of the irregularities in the records and have a bearing on the differences observed as between the negative and positive half-cycles.

Another discussion of this subject by A. C. Seletzky (Cleveland, Ohio) suggested that in view of the varying results obtained, a quantitative method of detecting the initial presence of corona should be used, as it would give more consistent results. Such a method he believes would be able to detect corona in parts of the insulator which are difficult, if not impossible, to observe accurately by visual means, even under the most favorable conditions and a darkened room.

### PREDETERMINATION OF A-C. BEHAVIOR OF DIELECTRICS

H. H. Race (Schenectady, N. Y.) discussed this subject and it is his belief that the paper presents some very interesting data but it does not suggest a physical explanation of the results. He was particularly interested in Fig. 5, because the variations of capacitance and loss with frequency are similar to corresponding curves calculated using a very definite physical picture; namely, Debye's theory of polar molecules. An analysis and comparison of the two theories were made which led to several more general and interesting conclusions.

# Baltimore & Ohio to Equip More Cars for Air-Conditioning



AN INITIAL ORDER for new and improved equipment for 78 passenger cars has been placed [with the York Ice Machinery Corporation of York, Pa.] by the Baltimore & Ohio Railroad, pioneer in train air-conditioning. The new equipment, like that employed in the initial installation, is self-contained in each car to permit flexibility of operation. Power for driving the equipment is obtained from a newly developed three-brush generator, axle driven through a special gear and pulley arrangement, and a new high-capacity storage battery. Refrigeration is carried out in a closed cycle. The refrigerating unit consists of a compressor, specially designed for use with Freon gas (dichloro-difluoro-methane) and driven by an electric motor with both high and low pressure cut-outs and gages. The new gas employed is a colorless, odorless, non-corrosive, non-combustible, and non-inflammable refrigerant which may be used in equipment passing through tunnels without any serious hazard to health. The new equipment is said to have 50 per cent increased capacity, but to require less space than that used by the B & O in their original installation. Either an air-cooled or cooling-tower liquifier may be used, depending upon operating conditions; identical results are expected with either type. The accompanying illustration shows a typical passenger car installation, in which may be noted the arrangement of equipment and air passages. The entire system is controlled from a push-button station near one end of the car.

Another discussion by F. M. Clark (Pittsfield, Mass.) told of determining the relative a-c. characteristics of 5-kva. oil-filled capacitors by means of the so-called d-c. leakage. This appears to be of greater value than insulation resistance measurements, but the work was not carried sufficiently far to predict successfully the power factor from the leakage results obtained; however, it was believed that this could be done.

W. A. Del Mar (Yonkers, N. Y.) also discussed this subject and brought out the fact that the practical control of power factor of impregnated paper now lies with the paper tests, where formerly it was essentially a matter of oil resistivity. This change occurred when manufacturers changed their paper from manila to wood pulp, and oil from petrolatum to cylinder oil. He believes that the practical problem has long since been solved, but it would be interesting to have the authors explain these facts in the light of their admirably developed theories.

### BREAKDOWN OF GLASS WITH ALTERNATING POTENTIALS

J. B. Whitehead (Baltimore, Md.) discussed this paper and found it difficult to accept the suggestion of Moon and Norcross, and now of these authors, that the intermediate stage of breakdown should follow a definite law.

W. A. Del Mar (Yonkers, N. Y.) discussed the authors' contention that three distinct regions of dielectric failure, instead of two, exist with alternating currents. He believes that the authors in justice to their thesis should give Fig. 4 with the experimental points plotted.

W. A. Hillebrand (Barberton, Ohio) discussed the nature of glass, the material used in these tests. He explained that glass is a physical solution, an electrolyte, the constituents of which are ionized, and that it has the high negative temperature coefficient of resistance characteristic of electrolytes. Furthermore, some of its physical properties are indefinite. Therefore, the discusser did not believe it was impossible that there should be a region of dielectric breakdown intermediately between the disruptive and thermal regions partaking of the nature of both and representing a transitional stage.

Another discusser, F. M. Clark (Pittsfield, Mass.) also drew attention to the nature of the material used. He believes that the conclusions drawn by the authors, even if accepted, should be limited carefully to glass of the type under discussion which also should be more clearly described than it was in the paper.

### MAGNET STEELS

This subject was discussed by W. A. Codd (Rochester, N. Y.) who believes that the paper checks experimentally Evershed's criterion of magnetic quality for magnet steels and apparently offered a considerably simplified design method in the nomogram presented. The discusser also inquired in detail about many points in this paper.

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**Editor's Note:** The remainder of these summaries of winter convention discussions is scheduled for inclusion in the May 1932 issue of ELECTRICAL ENGINEERING.

## Executive Committee of Institute Meets

A meeting of the executive committee of the American Institute of Electrical Engineers was held at Institute headquarters, New York, N. Y., on Wednesday, March 9, 1932, in place of the regular March meeting of the board of directors.

Present were: C. E. Skinner, *chairman*, and H. P. Charlesworth, J. Allen Johnson, W. S. Lee, F. W. Peek, Jr., W. I. Slichter, and C. E. Stephens, of the committee, and Assistant National Secretary H. H. Henline.

Resolutions were adopted in memory of the late National Secretary F. L. Hutchinson and Past-President Harold B. Smith, as published elsewhere in this issue.

Resolutions were adopted, authorizing and empowering H. H. Henline, assistant national secretary, to perform all of the duties of the office of national secretary until further order of the executive committee or the board of directors.

Approval was given to actions taken by the board of examiners at its meeting of March 2, 1932; and upon the recommendation of the board of examiners the following actions were taken upon pending applications: one applicant was elected to the grade of Fellow and two were transferred to the grade of Fellow; two applicants elected and 21 transferred to the grade of Member; 218 Associates elected; 99 Students enrolled.

The approval by the finance committee for payment of monthly bills amounting to $28,519.97 for January and $25,729.56 for February was ratified.

The assistant national secretary reported that upon being advised of the action of the board of directors in January, calling for a reduction in the expenses of the meetings for the remainder of the year 1932, the executive committee of the Southern District (No. 4) had voted to cancel the District meeting scheduled to be held in Memphis, Tenn., in November, 1932, with the idea that a meeting will be held the latter part of 1934 instead.

Appointment by the president of the following committee of tellers to canvass and report upon the ballots cast in the 1932 election of Institute officers, was confirmed: J. T. Wells, *chairman*, L. B. Bogan, H. B. Ely, C. S. Purnell, G. J. Read, R. H. Twiss, and Ernst Volckmann.

The resignation of J. C. Parker as a representative of the Institute on the standards council of the American Standards Association was presented, and the president was authorized to appoint a representative for the unexpired term of Mr. Parker, ending December 31, 1932.

Col. W. B. Jackson was appointed a representative of the Institute on the Commission of Washington Award, for the 2-year term beginning June 1, 1932, to succeed Prof. C. F. Scott, whose term expires at that time. Appreciation of the services rendered by Professor Scott in this capacity over a long period of years, was expressed.

The president was empowered to nominate for appointment by the president of the National Academy of Sciences, a representative of the Institute on the division of engineering and industrial research of the National Research Council, for the 3-year term beginning July 1, 1932, to succeed F. W. Peek, Jr., whose term expires at that time and who is ineligible for immediate reappointment.

Upon recommendation of the committee on education, it was voted to endorse the activity of the Society for the Promotion of Engineering Education in its summer schools for engineering teachers.

An invitation from the National Academy of Sciences to be represented by a delegate at the celebration of the one hundredth anniversary of the electrical discoveries of Joseph Henry, on the evening of April 25, 1932, in Washington, D. C., was accepted, and the president was authorized to appoint a delegate.

It was also voted to accept the invitation to send a representative to the celebration, on April 11, 1932, of the opening of the new patent office in Washington.

Other matters were discussed, reference to which may be found in this and future issues of ELECTRICAL ENGINEERING.

**Doctor Langmuir Receives Science Award.**—The annual award of $10,000 offered by *Popular Science Monthly*, this year went to Dr. Irving Langmuir, physicist, chemist, and associate director of the research laboratories of the General Electric Company. The following institute members were among the committee of eminent engineers and scientists which chose Dr. Langmuir: Dr. F. B. Jewett (A'03, F'12), vice-president of the American Telephone and Telegraph Company, *chairman;* Dr. C. F. Kettering (A'04, F'14) president and general director of the General Motors research laboratories; Dr. S. M. Kintner (A'02, M'03) vice-president of the Westinghouse Electric and Manufacturing Company; Dr. R. A. Millikan (M'22) chairman of the executive council, California Institute of Technology; Philander Norton (A'11) assistant to the president, Bell Telephone Laboratories; and Dr. Willis R. Whitney (A'01) vice-president and director of research of the General Electric Company.

**A.A.A.S. and Associated Societies to Meet at Syracuse.**—Following the custom established last year of holding annually a summer meeting of truly national character, the American Association for the Advancement of Science, together with associated societies, will hold their second annual summer meeting in Syracuse, N. Y., June 20–25, 1932. Syracuse University will act as host for the meeting. Dean H. P. Baker of the College of Forestry has been appointed chairman of the steering committee and has organized the various committees which are to function in making the stay of the 2,000 scientists, who it is expected will attend the meetings, a pleasant one. The facilities at Syracuse University have been found suitable as a meeting place for such a large group. In addition to the hotels, University accommodations will be available for housing the visitors during the week of the convention. Visiting scientists will be able to make excursions to any points of interest in the vicinity, and guides will be furnished for the various trips.

# Post-College Education Popular With Chicago Engineers

FOR NEARLY three years the educational committee of the Chicago Section of the Institute has been actively promoting the post-college education of engineers in that district. Prof. Edward Bennett, chairman of the Institute's committee on education, set forth the case for post-college education for engineers in his article in the JOURNAL of the Institute for April 1929, p. 310, and R. F. Schuchardt, then president of the Institute, gave further encouragement to the idea in his editorial on p. 259 of the same issue. The annual report of the committee on education under Professor Bennett's chairmanship was given in the JOURNAL for September 1929, p. 677, and amplifies the importance of stimulating interest in the systematic continuation of engineering education after college.

The Chicago Section actively took up the work of post-college education among engineers and has obtained surprisingly successful results. A progress report on activities of the education committee of this Section has been prepared by Burke Smith, chairman, and should be of interest to other Sections. The paragraphs following are taken from Mr. Smith's report:

An education committee for the Chicago Section was appointed in the summer of 1929 and has continued to function since that date. The committee at that time had no data to guide it, since no educational work of the nature here considered was being done by any engineering organization in Chicago. A questionnaire was sent to the membership requesting a reply from those members who would be interested in continuing their education by attending evening classes or lectures along certain specified technical lines. Out of some 1,200 members, replies were received from approximately 100, a rather meager response which in the light of the success of all courses offered indicates that questionnaires are of value only in so far as they are indicative of choice between different courses.

As a result of a preliminary study of the situation by the committee, the following conclusions were reached:

1. It appeared to be worth while to arrange for educational courses to be offered in the evening, a fee to be charged covering the cost of instruction.

2. While it is recognized that cultural subjects are of great value and interest to practising engineers, such subjects are offered by various educational institutions in Chicago or by correspondence courses and there appeared to be no need, therefore, for the Institute to arrange for courses of this nature.

3. It was felt that due to the limitations of the present 4-year engineering curriculum, practising engineers would be interested in technical subjects of a somewhat advanced nature which would supplement their undergraduate work.

4. In addition to the need for formal classroom work in advanced subjects, it was assumed that there is also a desire for lectures covering recent developments in physical science which would enable practising engineers to keep in touch with contemporary scientific progress.

5. It was proposed that any courses offered should be administered by an educational institution rather than by the Institute, thus relieving the Institute of the responsibility for arranging for instructors or lecturers, determining the form in which the subject matter should be presented, collecting fees, etc.

After a program of courses had been planned, it was decided to invite other engineering organizations in Chicago, such as the Western Society of Engineers and the Chicago Section of the Institute of Radio Engineers to join, so that a larger number of engineers might be interested and the enrolment in any courses offered might be increased correspondingly.

In accordance with the above policy, the following courses were offered, beginning in January 1930:

1. Engineering Economics. Classroom instruction, one session each week for ten weeks. This course was given by Armour Institute of Technology under the direction of Prof. E. H. Freeman; fee for the course, $10.

2. A lecture series on recent developments in electron physics and electrochemistry consisting of ten evening lectures, one per week, by members of the staff of the University of Chicago; fee for the series, $5. The following subjects were covered: the nature of the electron, the nature of heat, the nature of light, cosmical matter, molecular spectra and molecular structure, the arrangement in solids, modern theories of strong electrolytes, the electron in organic chemistry, the Werner coordination theory, and atomic species, isotopes and radioactivity.

The registration in engineering economics proved to be so large, 126 persons, that it was necessary to divide the class into two sections. Early in the fall of 1930 arrangements were made with Armour Institute of Technology to repeat the course, and a second class was organized with a registration of 39.

The registration in the lecture series on recent developments in electron physics and electrochemistry was 290. In view of the evident interest in these lectures an additional series of three lectures on electronics and three lectures on the theory of conductors and dielectrics was offered beginning in October 1930 and covering the following subjects:

Classical electron theory and positive rays, modern conceptions of the electron, television and the electron, conduction in gases, conduction in liquids and solids, and conduction in dielectrics.

The registration for the first three lectures was 355 and for the last three, 208. The fee for each series of three lectures was $1.

The total number of registrations for the courses offered during the calendar year 1930 amounted to 1,018.

Activities during 1931 consisted of the following, all offered by the University of Chicago:

1. A classroom course in transient phenomena and advanced circuit theory offered in January in connection with the evening school which the University maintains in the downtown district of Chicago. The registration was 43, and the regular tuition fee of $12.50 for 12 weeks was charged. The University of Chicago does not have an engineering school, but arrangements were made to secure Prof. E. B. Paine of the University of Illinois as instructor.

2. A classroom course in modern circuit theory beginning in October and continuing for 24 weeks. The registration was 40, and the regular tuition fee of $25 charged.

3. A series of three lectures on acoustics given in October. Registration, 210. Fee for the series, $1.50.

All of the above courses were open to any who cared to register for them and were offered with the cooperation of the Chicago Section of the Institute of Radio Engineers and the Western Society of Engineers. From 28 to 38 per cent of those who attended were members of the Institute.

The question of fees was discussed with the educational institutions and the amount to be charged for each lecture series was determined on the basis of meeting expenses with the expected enrolment. It was understood that if expenses were not covered by the fees in the initial courses the Institute would share with the educational institutions in making up the deficit. For the classroom courses offered by the University of Chicago, it was understood that none would be given if a sufficient number of students was not enrolled at the first meeting to make it possible to meet expenses. Those who had not been enrolled previously in the University were charged a matriculation fee for these courses.

## CONCLUSIONS

Based on the record of a registration of over 1,000 in the courses which were offered during 1930, and a continuation of interest during 1931, there can be no doubt that under the conditions existing in Chicago there is a desire for post-college evening courses of the following general nature:

1. Classroom work covering advanced subjects such as are usually given in resident post-graduate courses in mathematics, physics, and engineering subjects.

2. A connected series of lectures on selected topics in the physical sciences, given by specialists and designed to enable graduates to keep up with contemporary advances in these fields.

The question arises as to whether the demand for educational courses of the type described will continue. It seems that this will depend upon how well the local education committee succeeds in interpreting and putting into effect the wishes and needs of the members. Evening instruction in engineering subjects of an undergraduate level is not a new idea. That evening instruction of an advanced nature can be offered successfully over a period of years is shown by the experience of the Chicago Section of the American Chemical Society, which since 1923 has provided for its members instruction in advanced courses in chemistry, with results which have been uniformly successful. A description of this project is given in an article by Arthur Guilladeau and W. V. Evans in the *Journal of Chemical Education* for November 1928. Another example is that of the Polytechnic Institute of Brooklyn which for a number of years has maintained evening classes in engineering subjects of graduate level.

It is believed that if a definite sequence of courses is laid out requiring two or three years for completion, there will be many engineers who will wish to enroll for the entire series. Such a sequence may be selected easily although obviously the particular courses which may be offered will depend upon the possibility of arranging for instructing personnel.

Following is a brief list of subjects which might form the nucleus of such a sequence. Many of these subjects are now offered as resident advanced courses in our larger engineering schools and universities. Some are more suitable for classroom work and others for a lecture series. The list of course could be greatly extended:

**Engineering economics, differential equations for engineers, vector analysis with engineering applications, electric wave theory, Heaviside's operational calculus with applications, transient phenomena and advanced circuit theory, advanced theory of electrical machinery, theory of vacuum tubes and their circuits, acoustics, modern theories of magnetism, conduction of electricity through gases, modern theories of the electron, theory of conductors and dielectrics, the photoelectric effect, and the quantum theory of radiation.**

Where facilities for experimental work and credit toward an advanced degree can be offered in connection with evening work a larger number of students will be attracted. Such facilities are available to evening students in only a few of the larger centers, however, and in most cases the instruction must of necessity be theoretical. In this connection it is possible that reading courses or a reading list service covering advanced subjects for the guidance of those engineers who do not live within easy reach of educational centers would be welcomed. At least one large university is now offering such a service to its alumni to enable them to follow a systematic course of reading in fields in which they are particularly interested. Results in Chicago to date indicate more interest in courses in pure science than in advanced engineering subjects.

It is well known that many industrial organizations offer technical training to their employees either in cooperation with the universities or as instruction courses under the direction of their own staffs. Such training is usually along special lines pertaining to the particular industry and does not supply the need for more fundamental courses or for work leading to an advanced degree. The educational activities of industrial organizations should supplement rather than conflict with any program which may be set up by the Institute Sections.

An educational program is a joint undertaking and in order to be successsful the responsibility for it must be shared by both the educational institutions and the engineers. There is ample evidence that the colleges and universities are alive to the situation and are willing to do their part. Now, therefore, is an opportune time for the Sections, through their education committees, to take the lead in making known their needs and developing plans to satisfy these needs in cooperation with the universities.

In conclusion, it may not be amiss to take stock of the results which may be expected to accrue over a period of years from a systematic educational program such as is here outlined:

**1. The cooperation of educational institutions and engineering societies will result in a closer affiliation of all the groups concerned.**

**2. The engineers individually and the industries in which they are employed will gain from the further training and broader outlook of those who participate.**

**3. An increased appreciation of the value of the Institute to members and non-members alike will result.**

In view of the evident desire on the part of practising engineers for a continuation of engineering education, and the future possibilities in this field, the statement from the report of the committee on education which was quoted at the beginning of this article does not seem to over-emphasize the importance of the movement and the need for adequate provision for a program of post-college education.

## M.I.T. Plans New Division of Studies

The distribution of its curriculum into five distinct branches, namely, school of science, school of engineering, school of architecture, division of humanities, and division of industrial cooperation, was announced March 10, 1932, by Dr. Karl T. Compton, president of Massachusetts Institute of Technology. The following appointments have been made accordingly: Dr. Vannevar Bush (A'15, F'24) a member of the faculty of electrical engineering since 1923, vice-president and dean of engineering; Dr. Samuel C. Prescott, dean of science; Prof. William Emerson, dean of architecture.

Doctor Compton is quoted as having stated that this new plan is a natural extension of an administrative plan started two years ago in the appointment of a chairman of the corporation and a president of the M.I.T. The new subdivision recognizes the five major aspects of the work, the three schools comprising those departments in which degrees are given, and the two divisions, essentially for "service" purposes, to give the students the benefit of a further cultural training and background deemed essential to a well-balanced training, and designed to make as effective as possible the assistance which the M.I.T. desires to render in various ways in solving the technical problems of business and industry.

What is counted an important feature of this new plan is definite recognition of the graduate school. With every evidence that this work is becoming relatively more and more important, it has seemed advisable to provide more adequately for its constructive administration through the establishment of a graduate school embracing

## The Engineer—a Parable

ONE DAY three men, a Lawyer, a Doctor, and an Engineer, appeared before St. Peter as he stood guarding the Pearly Gates.

The first man to step forward was the Lawyer. With confidence and assurance, he proceeded to deliver an eloquent address which left St. Peter dazed and bewildered. Before the venerable Saint could recover, the Lawyer quickly handed him a writ of mandamus, pushed him aside, and strode through the open Portals.

Next came the Doctor. With impressive, dignified bearing, he introduced himself: "I am Dr. Brown." St. Peter received him cordially. "I feel I know you, Dr. Brown. Many who preceded you said you sent them here. Welcome to our City!"

The Engineer, modest and diffident, had been standing in the background. He now stepped forward. "I am looking for a job," he said. St. Peter wearily shook his head. "I am sorry," he replied, "we have no work here for you. If you want a job, you can go to Hell." This response sounded familiar to the Engineer, and made him feel more at home. "Very well," he said, "I have had Hell all my life and I guess I can stand it better than the others." St. Peter was puzzled. "Look here, young man, what are you?" "I am an Engineer," was the reply. "Oh yes," said St. Peter, "Do you belong to the Locomotive Brotherhood?" "No, I am sorry," the Engineer responded apologetically, "I am a different kind of Engineer." "I do not understand," said St. Peter, "what on Earth do you do?" The Engineer recalled a definition and calmly replied: "I apply mathematical principles to the control of natural forces." This sounded meaningless to St. Peter, and his temper got the best of him. "Young man," he said, "you can go to Hell with your mathematical principles and try your hand on some of the natural forces there!" "That suits me," responded the Engineer, "I am always glad to go where there is a tough job to tackle." Whereupon he departed for the Nether Regions.

And it came to pass that strange reports began to reach St. Peter. The Celestial denizens, who had amused themselves in the past by looking down upon the less fortunate creatures in the Inferno, commenced asking for transfers to that other domain. The sounds of agony and suffering were stilled. Many new arrivals, after seeing both places, selected the Nether Region for their permanent abode. Puzzled, St. Peter sent messengers to visit Hell and to report back to him. They returned, all excited, and reported to St. Peter:

"That Engineer you sent down there," said the messengers, "has completely transformed the place so that you would not know it now. He has harnessed the Fiery Furnaces for light and power. He has cooled the entire place with artificial refrigeration. He has drained the Lakes of Brimstone and has filled the air with cool perfumed breezes. He has flung bridges across the Bottomless Abyss and has bored tunnels through the Obsidian Cliffs. He has created paved streets, gardens, parks and playgrounds, lakes, rivers, and beautiful waterfalls. That Engineer you sent down there has gone through Hell and has made of it a realm of happiness, peace, and industry!"

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**By D. B. Steinman, President of the New York State Society of Professional Engineers, and Past-President of the American Association of Engineers. Reprinted from "The American Engineer" for January 1932.**

engineering, science, and architecture. Notwithstanding this new subdivision, however, the faculty as a whole will continue to be the final authority in matters of educational procedure. The new organization provides for an administrative council, an informal organization which will hold weekly meetings in order to keep fully informed of the progress of various departments. This council will consist of President Compton, Vice-President Bush, members of the executive committee, Dean Prescott, Dean Emerson, the president of the alumni association, the chairman of the faculty, the director of the division of industrial cooperation, the deans of graduate students and students, and the bursar.

## To Institute Members Planning Trips Abroad

Members of the Institute who contemplate visiting foreign countries are reminded that since 1912 the Institute has had reciprocal arrangements with a number of foreign engineering societies for the exchange of visiting member privileges, which entitle members of the Institute while abroad to membership privileges in these societies for a period of three months and members of foreign societies visiting the United States to the privileges of Institute membership for a like period of time, upon presentation of proper credentials. A form of certificate which serves as credentials from the Institute to the foreign societies for the use of Institute members desiring to avail themselves of these exchange privileges may be obtained upon application to Institute headquarters, New York. The members should specify which country or countries they expect to visit, so that the proper number of certificates may be provided, one certificate being addressed to only one society.

The societies with which these reciprocal arrangements have been established and are still in effect are: Institution of Electrical Engineers (Great Britain), Société Française des Electriciens (France), Association Suisse des Electriciens (Switzerland), Associazione Elettrotecnica Italiana (Italy), Koninklijk Instituut van Ingenieurs (Holland), Verband Deutscher Elektrotechniker E. V. (Germany), Norsk Elektroteknisk Forening (Norway), Svenska Teknologforeningen (Sweden), Stowarzyszenie Elektrykow Polskich (Poland), Elektrotechnicky Svaz Ceskoslovensky (Czechoslovakia,) The Institution of Engineers, Australia (Australia), Denki Gakkwai (Japan), and South African Institute of Electrical Engineers (South Africa).

**Touring Arrangements for I.E.C. Congress.**—For those going to the International Electrical Congress to be held this summer in Paris, France, provisions have been made with Thomas Cook & Son to provide transportation arrangements for those desiring to avail themselves of this service. According to the best information available, the congress will open Monday, July 4, 1932, and close July 12. Accordingly, Thomas Cook & Son thinks that the Cunard liner "S. S. Franconia," leaving New York, N. Y., June 24 and due to arrive at Havre, France, July 2, will be the most convenient and satisfactory vessel for such a party, and it already has reserved some space on this boat. The services of this organization also will be available for arranging subsequent tours in Europe, and to assist in securing passports, and supplying travelers' checks. Inquiries should be addressed to Thomas Cook & Son, either in Boston, New York, or other convenient cities, as early as possible.

**Dr. W. D. Coolidge Receives Washington Award.**—Following a dinner and reception February 24, 1932, at the Hotel Sherman, Chicago, Illinois, Dr. W. D. Coolidge (A'10) associate director of the research laboratory of the General Electric Company of Schenectady, N. Y., was presented the Washington Award for 1932, "in recognition of devoted, unselfish, and preeminent service in advancing human progress." Doctor Coolidge is to be the eleventh so honored by the award commission, the first presentation being to President Hoover in 1919. Dr. H. W. Chase, president of the University of Illinois, delivered the principal address of the evening, evaluating the importance of research in the present social order. Presentation of the award was made by F. D. Chase, president of the Western Society of Engineers, which administers this award founded 16 years ago by John Watson Alvord. A personal item containing news of this award to Doctor Coolidge was given in Electrical Engineering for March 1932, p. 210–1.

# Letters to the Editor

## Discussion of "E.E." Articles Invited

Institute members and subscribers hereby are invited to discuss in these columns any of the articles appearing in Electrical Engineering. Because of the many letters received, it is not feasible to publish all, but an endeavor will be made to include those which appear to be of the most general interest. The shorter letters in general are more popular; hence conciseness is a desirable quality in all cases. Electrical Engineering reserves the right to publish letters either in full or in part.

## Edison's Self-Consistency

*To the Editor:*

With all that we are saying and reading about our beloved Edison these days, a thought came to me that is quite different from those which I have heard expressed by any one. Others may have had it and not expressed it, fearing that it was pointing out a limitation in his efforts, and ability. To me, it shows his strength of character and good judgment.

At this time, when all his admirers are vying with each other in telling of his innumerable accomplishments, it may seem disrespectful to point out a field of electrical endeavor that he consistently avoided. Edison unquestionably appreciated that to succeed in any line even he must be enthusiastic, and his early commercial fight with those who pioneered in a-c. development naturally left him without enthusiasm in this direction.

A lesser mind, as the commercial possibilities of alternating current rapidly developed, would have been tempted to join in the effort and thus share in the commercial rewards. Not so for Edison, who was always true to himself. The pioneer inventors and engineers who were working with a-c. generators, motors, and transformers would have had a formidable competitor in Edison had he decided to enter this field. He evidently decided that he had abundant opportunities elsewhere.

Is there not in this a lesson teaching the young engineer to select, if possible, lines of work that appeal to his enthusiasm rather than some that give perhaps better immediate prospect of higher financial returns? One must obtain unusual results to get superior rewards and such results are seldom attained without the assistance of enthusiasm.

Very truly yours,
WALTER S. MOODY (F'12)
(Consulting Electrical Engineer,
155 Dawes Ave., Pittsfield, Mass.)

## Diversification in Articles Commended

*To the Editor:*

The letter of protest tendered by Mr. F. G. Strong of Wethersfield, Connecticut, against the article "Nerve Injuries from Electric Shock," and appearing in Electrical Engineering (Feb. 1932, p. 138) is at once a concentrated source of astonishment and argument to me.

This attitude seems to fortify the impression gained by me during the past two years that Electrical Engineering and its predecessor, the Journal of the A.I.E.E, caters primarily to the power aspects of the electrical engineering profession. The appearance of the aforementioned article and various others of its type, not necessarily dealing with the medical aspects of electricity, has accomplished a great deal in dispelling this illusion from my mind.

With due respect for Mr. Strong's more experienced viewpoint, I nevertheless desire to commend Electrical Engineering in its display of the appreciation that the electrical engineering profession does not comprise a group of power engineers solely; but, that it also includes engineers associated with a multitudinous array of other valuable applications of that wonderful realm of reality—Electricity.

Very truly yours,
M. K. Kunins (A'32)
(Jr. U.S. Radio Inspector,
Radio Div., Dept. of Commerce, Buffalo, N. Y.)

## Unity Power Factor for Neon Tube Signs

*To the Editor:*

The article by McNeely and Law entitled "Unity Power Factor for Neon Tube Signs" and appearing in the November 1931 issue of ELECTRICAL ENGINEERING, p. 886–8, leaves the reader with the impression that the constant current circuit is the best and most economical solution, in all cases, of the problem of producing luminous tube signs with high power factor. I am writing to point out some of the reasons why this circuit has not been generally adopted.

The data given by the authors relates to the special case of a small sign with a fixed load of tubing. It is not indicated whether calculations or tests were made on larger signs and transformers with varying lengths of tubing. From the data given it appears that the tests reported were made on transformers of about 2,500 volts open circuit, delivering 15 milliamperes to the tubing. Such transformers are generally used with small window or show-case signs, and because the load taken by them is small and they are usually connected to circuits carrying a relatively large load of incandescent lighting, the power factor of the individual sign is not of great importance.

The problem of power factor is most important in the case of large signs which employ transformers of 12,000 or 15,000 volts open circuit rating, delivering approximately 25 milliamperes to the tubing. There are some problems encountered with these larger transformers which do not apply to the smaller, lower voltage units.

As the authors point out, when the constant current circuit is employed the transformer primary winding will take a substantially constant current, even when the secondary of the transformer is open-circuited. Under these conditions the entire current becomes exciting current, and the secondary voltage is limited only by the saturation of the core. Since it is not feasible to insure that the transformer may never be operated with open-circuit, the use of the constant current circuit therefore involves a serious hazard to the insulation of the transformer, and the cable, electrodes, etc., in the sign. Furthermore, the open-circuit voltage of transformers used in luminous tube signs is definitely limited by the National Electrical Code.

In determining the amount of capacity required to obtain maximum power factor correction with commercial transformers the authors have evidently connected the capacitors directly across the 110-volt circuit. They have not taken account of the generally accepted arrangement of operating the capacitor at higher voltage, using the primary winding of the transformer as an auto-transformer to obtain this voltage. Since the corrective effect of a capacitor is proportional to the square of the voltage, this arrangement results in substantial economy. A 15,000-volt 25-milliampere transformer carrying a normal load of tubing, can be made to operate at a power factor well over 90 per cent by the use of as little as 5$\mu$ of capacity operating at about 500 volts. Of course the capacitor must be suitable for use on this voltage, but most modern capacitors are, and because of mechanical limitations, very little can be gained by rating them at a lower voltage.

The fact that the installation using the constant current circuit can, and probably must, be made up of several individual devices, is likely to prove a disadvantage rather than an advantage. In the case of small window or show-case signs it is desirable that the sign manufacturer assemble the sign complete, leaving the installation job as simple as possible. In the case of large outdoor signs, this is also true, with the additional consideration that such signs frequently contain many transformers, and the use of separate reactors and capacitors installed inside the building, with separate circuits to the individual transformers would be prohibitive because of cost and complication.

A capacitor sufficient for power factor correction can be placed in the same case with the conventional transformer, with a small increase in one dimension only, providing a self-contained high power factor unit, interchangeable as to mounting dimensions with the conventional low power factor transformer.

Still another difficulty that might be expected with the constant-current circuit results from the fact that many of the higher voltage transformers are operated with the midpoints of the secondary windings grounded, in order to limit the voltage that may be applied under abnormal conditions to the tubing and other parts of the circuit. Accidental grounds may, and do, occur in the high voltage circuit. With the conventional high reactance transformer the current in the winding thus short-circuited is limited by the impedance of the transformer to a safe value. With the constant-current circuit, the primary would continue to force a definite number of ampere-turns through the secondary winding, these ampere-turns dividing between the two halves of the winding in inverse proportion to the impedances.

With one half of the winding short-circuited and the other half open-circuited or loaded, the short-circuited half would supply most of the ampere-turns, with resulting over-load and probable burn-out.

Very truly yours,
R. H. CHADWICK (A'17, M'26)
(Engineer, Transformer Division, General Electric Co., Fort Wayne, Ind.)

## Electrical Precipitation

*To the Editor:*

In connection with the article "Electrical Precipitation," by Simon and Kron, which appeared in the February issue of ELECTRICAL ENGINEERING, p. 93–5, I desire to point out a few of the results which have been obtained in the development of theory and technique by those scientists and engineers who have devoted so much effort to this art during the past twenty years, both here and abroad.

To mention but one of the many studies which have been made, E. Anderson and other engineers of the Western Precipitation Company carried on extensive experiments at Santa Cruz in 1919, using not a single size pipe electrode as reported by Simon and Kron, but 3-in., 4-in., 6-in., 9-in., and 12-in. tubes of from 5 ft. to 20 ft. in length. One of the many important results of this particular study was the development of a formula for precipitator efficiency, $\eta = 1 - K^t$, in which $K$ is a "constant." Simon and Kron use a constant $\alpha$. If we let $K = e^{-\alpha}$ we find the formula developed by them to be identical with that of Anderson and equivalent to similar formulas developed by various European investigators, notably Heinrick and Deutsch.

It must be emphasized, however, that the manner in which this formula is used is of vital importance. A point long recognized by precipitation engineers but overlooked in the reports of the Simon and Kron investigation is the fact that the "constant" $\alpha$ (or $K$) is not nearly so constant as might be desired; nevertheless, the formula is used continually in precipitator design, but always with due consideration of its recognized limitations. These limitations have made those who best appreciate them extremely hesitant in the publication of their results.

The apparatus used for the measurement of dust concentration and described by Simon and Kron, is not used in electrical precipitation investigation because of its inherent inaccuracy as a gage of dust content when there is a variation in the size of the dust particle. It has been reported by Tolman (*Journal of American Chemical Society*, V. 41, 1919, p. 307) that the light beam strength through a dust laden gas varies with the concentration of dust between limiting formulas in which, for small particles, the particle diameter appears directly as the cube, and for the large particles inversely as the first power. The Tyndall beam type of instrument is therefore of little value in the comparison of inlet and outlet concentrations if there is any marked change in the dust particle size between the two points of measurement. An electrical precipitator will produce such a change in dust particle size to a very marked degree, especially in the case of particles of the kind used by Simon and Kron.

This fundamental characteristic of the measuring device is doubtless responsible for the difference which exists between the conclusions reached by Simon and Kron and the facts established by engineers and scientists who, under the auspices of Lurgi Apparatebau-Gesellschaft, Siemens-Schuckertwerke, Lodge-Cottrell, Ltd., Western Precipitation Company, and Research Corporation, have been working on this problem for more than a score of years. I refer especially to the statement that efficiency is a positive exponential function of the current and the statement that the voltage, in so far as it affects the electrical field, has little effect on efficiency.

Very truly yours,
J. C. HALE (A'10, M'29)
(Electrical Engineer, Research Corp., Bound Brook, N. J.)

## Has Man Benefited by Engineering Progress

*To the Editor:*

Responding to the invitation to submit comments on the question "Has Man Benefited by Engineering Progress" I am impressed by the letter of Professor Rittenhouse, in ELECTRICAL ENGINEERING, January 1932, p. 59, as discussion of the question can run riot in the absence of more exact definition. If man is benefited by cheap bathtubs, talkies, radio crooners, automobiles, etc., there is no room for discussion. Science and engineering gave these and some others less pleasant to contemplate. If, however, benefit to mankind results from cultivation of what is beautiful, using the word in its broadest sense, and suppression of what is ugly in the world and in human relations, the question becomes debatable. It might be possible to prepare an impressive argument to show that man would be better off if every child born with a scientific mind had died in infancy. What is the formula for human benefit? *Homo sapiens* is treated in the mass in government statistics, but individually he is everything from the noblest to the lowest of earthly creatures. Anything that promotes a higher average of character and mentality would be a benefit, and perhaps engineering has helped in this direction.

Mr. Kohn wants engineers to "work out a new vision of human relations" but that does not seem to be a hopeful job for the profession. I wonder if a brand new engineering vision would be more popular than that given in "The Sermon on the Mount." From a practical point of view, would it not be better to do less dreaming about a new social scheme, and more hard work to make the existing scheme better?

The membership of our national organizations constitutes a great body of skilled engineers and a host of men of wide practical business experience. They and their predecessors have given the United States the machine age civilization that is so much admired. They should be worshipped as were the priests of Ammon; but on the contrary the public and the politicians treat them rather like djinns ordered out to perform miracles, which, these being done, are stored away in bottles. If the symposium includes the question as to what engineers should do to benefit mankind, then I suggest that American engineers try to break out of the bottle and take their proper place in public affairs. Vast sums have been, are being, and will be, squandered on governmental projects that come directly within the province of engineers. The people naturally cannot form an intelligent opinion of such undertakings, those who should guide them are ignored, and the political promoters have their way. I cannot do better than to refer to the address on this subject by W. S. Lee, published in ELECTRICAL ENGINEERING for August 1931, p. 641–2. It seems to be a sad fact that the engineer has no real standing with the American public. True, we have an engineer as President of the United States; but did that fact count in his election? I doubt it, for he gets no consideration as such, and if instead he had been a first-class politician, he would probably have had better support. If engineers enjoyed public esteem, would it not have been a natural procedure to leave, so far as possible, any purely engineering question to the judgment of an engineer president? The prolonged inane discussions of Muscle Shoals in Congress is a case in point. Any competent engineer could have cut that discussion short with a few facts; but none was given the opportunity. This country has the most highly developed electric power supply in the world, and consequently, an abundance of experts on the subject; yet the United States Senate seriously discussed supplying electricity to the public from that chunk of concrete in the Tennessee River, where the flow is as unreliable as German reparations. Public waste makes private want, and engineers can benefit mankind as represented by the people of the United States if they can find a way to establish an influence in such public affairs as are in their own field, and respecting which they only are competent to form sound decisions. I do not know how this can be done, but it is well worth our attention both as engineers who detest economic crimes and as patriotic citizens. It might be worth while first to try to discover why engineers are not consulted in advance on government projects, as they are in similar private undertakings? Perhaps it is because our profession is too modest or too timid to proclaim the truth so that the taxpayer may at least know in advance what is coming to him. Mr. Hoover recently said that our governments, federal, state, etc., are "engaged in constant attempt to solve a multitude of public relationships to these tools which the engineers . constantly force to the very doorstep of the government;" to which he added "These problems of public relations are unsolvable without the technical assistance of the engineer himself." In concluding his address the President of the United States insisted that engineers have the obligation to contribute to the public service. If we have the ability, persistence, judgment, and perhaps self-sacrifice to take on the obligation, we may then benefit our countrymen, if not all mankind.

Very truly yours,
F. V. HENSHAW (A'89, M'95, Member for Life) (Wood, Struthers, & Co., 20 Pine St., New York, N. Y.)

### Speakers for Washington Bicentennial Celebrations

During the remainder of 1932, many celebrations will be held in commemoration of the 200th anniversary of the birth of George Washington. The American Engineering Council is preparing a list of speakers who are especially qualified to address engineering groups upon the engineering features of George Washington's career, and has requested the Institute to supply some names.

Members of the Institute who would be willing to prepare such addresses to be delivered in their localities are requested to send prompt notification to Institute headquarters, 33 West 39th St., New York, N. Y.

**Specifications for Electrical Heating Elements.**—The American Society for Testing Materials is seeking comments on two recently adopted specifications, as follows: tentative specifications for "Drawn or Rolled Alloy, 80 per cent Nickel, 20 per cent Chromium, for Electrical Heating Elements" (B82–31T) and "Drawn or Rolled Alloy, 60 per cent Nickel, 15 per cent Chromium, and Balance Iron, for Electrical Heating Elements" (B83–31T). Comments on tentative method of "Test for Determining the Temperature-Resistance Constants of Resistance Alloys" (B84–31T) are also requested. Communications relative to the above should be addressed to R. E. Hess, American Society for Testing Materials, 1315 Spruce Street, Philadelphia, Pa., from whom copies of the specifications may be obtained.

## American Engineering Council

### Study Being Given Muscle Shoals Legislation

Dr. H. E. Howe of Washington, D. C., Prof. Charles F. Scott (A'92, F'25, HM'29, and past-president) of Yale University, New Haven, Conn., and J. Dyer of Nashville, Tenn., have been appointed by the American Engineering Council to study the Muscle Shoals measure introduced in the House by Representative E. B. Almon of Alabama.

The purpose of the Almon bill is, first, to aid American agriculture and to provide for national defense by the employment of the Muscle Shoals project, privately operated primarily for the production of fertilizer; and second, to make available for the production of chemical products any surplus of the Government owned resources.

The bill would create the Muscle Shoals Corporation of the United States, the directors of which would be authorized to lease for not more than fifty years the Muscle Shoals properties of the government. It also provides for an appropriation of $5,000,000 to build Cove Creek Dam.

The American Engineering Council, it was also announced, is opposed to the Muscle Shoals legislation sponsored by Senator George W. Norris of Nebraska "to provide for the national defense by the creation of a corporation for the operation of the government properties at and near Muscle Shoals in the state of Alabama, to authorize the letting of the Muscle Shoals properties under certain conditions, and for other purposes." This resolution was reported in the Senate, March 9, 1932, by the committee on agriculture and forestry. A similar resolution by Representative W. F. James of Michigan has been referred to the committee on military affairs of the House. These resolutions are identical and contain approximately the same proposals as the legislation which passed the Seventy-first Congress and was vetoed by the President.

## Engineering Foundation

### Plans for Study of Industrial System Discussed

At a dinner meeting of the Engineering Foundation on February 18, 1932, in New York, N. Y., consideration was given to plans for a study of the industrial system. Representatives from the American Engineering Council, the planning committee, United Engineering Trustees, Inc., and the Engineering Foundation, together with several special guests, brought the total attendance to 37.

For several years there has been a growing sense of obligation among members of the Engineering Foundaton to undertake from the engineer's point of view, research bearing upon economic and other humanistic problems. In September 1931, the United Engineering Trustees, Inc. submitted a proposal for a study of the industrial system to the Foundation, and the latter has since been giving the subject earnest consideration. The planning committee appointed is cooperating with the American Engineering Council.

Valuable suggestions were offered during the discussion at this meeting, and the need for a thorough study was emphasized. Definite suggestions were made and the desirability of cooperating with members of other professions was brought out. However, the valuable background of thought, habit, and experience of the engineer should be the center around which this cooperation should be built up. The necessity for courage and determination in the study of industrial problems was emphasized by several of the discussers, all of whom agreed as to the tremendous benefits which may be secured from such a study.

# Annual Report Issued by United Engineering Trustees, Inc.

IN THE annual report of United Engineering Trustees, Inc., for 1931, submitted by John V. N. Dorr, president, and Alfred D. Flinn, secretary, it is pointed out that the assets for which the corporation is responsible total $3,425,957.52, exclusive of the library and the John Fritz Medal fund. The report also mentions that outstanding among events of 1931 was the fourth gift of Ambrose Swasey, founder of the Engineering Foundation; this gift of $250,000 raised the total to three-quarters of a million dollars.

Through the will of E. H. McHenry, a well-known consulting engineer, late of Philadelphia, Pa., Engineering Foundation benefited to an additional amount estimated at approximately $400,000.

Early in November, United Engineering Trustees, Inc., consented to serve as treasurer and accountant for the Professional Engineers Committee on Unemployment. It is continuing to perform these services.

The development committee in December submitted a full report of its extensive studies for providing needed additional accommodations for the engineering societies. The Engineers' Club joined in this work which was devoted largely to a scheme for an "engineering center" but owing to business conditions no active steps are now feasible.

Through recommendation of the Trustees, Engineering Foundation in examining the possibilities of an engineering study of the industrial system. In passing to the summary of the financial report, it is worthy of note that all departments again closed the year without deficits.

### Summary of 1931 Financial Report

| | | |
|---|---|---|
| **Operation of Building** | | |
| Credit Balance January 1, 1931 | $10,636.73 | |
| Less Adjustment 1930 | −25.00 | -$10,611.73 |
| Building Revenue 1931 | 126,837.37 | |
| Building Expenditures 1931 | 115,546.96 | 11,290.41 |
| Total | | $21,902.14 |
| Annual Payment to Dep. and Renewal Fund | $12,000.00 | |
| Payment to Reserve for Future Fire Insurance | 1,550.00 | 13,550.00 |
| Credit Balance December 31, 1931 | | $8,352.14 |
| **Operation of Library** | | |
| Maintenance Revenue | $50,674.96 | |
| Maintenance Expenditures | 52,011.70 | |
| Debit Balance for year 1931 | −1,336.74 | |
| Credit Balance from preceding years | 5,688.95 | |
| Total Credit Balance December 31, 1931 | | $4,352.21 |
| Service Bureau Revenue | $17,031.56 | |
| Service Bureau Expenditures and Adjustments | 17,422.17 | |
| Debit Balance for year 1931 | −390.61 | |
| Credit Balance from preceding years | 4,733.96 | |
| Total Credit Balance December 31, 1931 | | $4,343.35 |
| **Funds and Property** | | |
| Funds held by U.E.T., Inc. Dec. 31, 1931 (book value) | | |
| Depreciation and Renewal Fund | | $303,397.14 |
| General Reserve Fund | | 3,934.40 |
| Engineering Foundation Fund | | 529,283.65 |
| Engineering Foundation Fund (4th Swasey Gift) | | 253,696.50 |
| Henry R. Towne Engineering Fund | | 50,115.63 |
| Library Endowment Fund | | 174,544.32 |
| Edward Dean Adams Fund | | 100,000.00 |
| Total | | $1,414,971.64 |
| Real Estate owned, cost to Dec. 31, 1931 | | $1,987,793.92 |
| Operating cash and petty cash | | 10,092.63 |
| Accounts Receivable | | 5,585.83 |
| Endowment Committee Loan Receivable | | 1,700.00 |
| Unexpired Fire Insurance Premiums | | 1,213.50 |
| Fire Insurance Fund | | 4,600.00 |
| Total Property which U.E.T., Inc. owns or holds | | $3,425,957.52 |
| Value of Library (as appraised approximately for Insurance) | | $483,000.00 |
| John Fritz Medal Fund (Custodian) | | 3,500.00 |

# Election Held by Engineering Foundation

At its annual meeting February 18, 1932, the Engineering Foundation board reelected as its chairman H. Hobart Porter (A'96, M'12, Life Member) president of the American Water Works and Electric Company, Incorporated, New York, N. Y.; George W. Fuller, consulting engineer, former vice-president of the American Society of Civil Engineers, New York, N. Y., and a member of the firm of Fuller and McClintock, was made vice-chairman. Second vice-chairman is C. E. Skinner (A'99, F'12) president of the A.I.E.E., and assistant director of engineering for the Westinghouse Electric and Manufacturing Company, E. Pittsburgh, Pa. George D. Barron, mining engineer, of Rye, N. Y., and D. Rovert Yarnhall, of Philadelphia, Pa., vice-president of the American Engineering Council, were elected to the executive committee. Dr. A. D. Flinn continues as secretary and director.

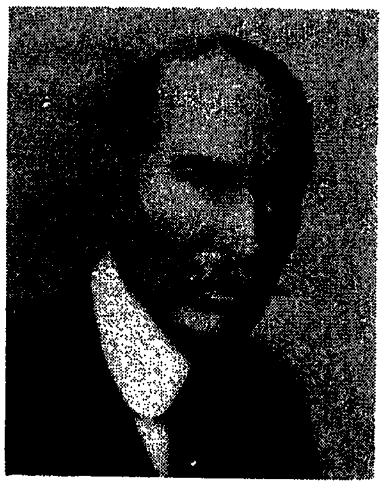
New members and reelected members of the Engineering Foundation board whose terms began at the annual meeting on February 18, 1932, are E. De. Golyer, New York, N. Y.; H. P. Charlesworth (F'28) representing the A.I.E.E., New York, N. Y.; E. R. Fish, Hartford, Conn.; G. G. Crawford, Pittsburgh, Pa.; H. Hobart Porter (M'12) New York, N. Y.; and H. A. Kidder (F'29) New York, N. Y.

# Personal

A. S. MILLER (A'08, F'12) vice-president of the Bartlett Hayward Company, engineers, New York, N. Y., at the January 14, 1932 meeting of the Engineering Societies Library board was reelected chairman and W. I. SLICHTER (A'00, F'12) was made vice-chairman. Mr. Miller is a native of Richmond, Virginia; since his graduation from Stevens Institute of Technology in 1888 he has had extensive experience in public utilities. In 1911, with Dr. A. C. Humphreys he formed the consulting firm of Humphreys and Miller, Incorporated, an activity which he continued until 1918 when he became vice-president of the Bartlett Hayward Company. He was appointed to the library board by the American Society of Mechanical Engineers. Professor Slichter, already well known in the annals of the A.I.E.E. as manager (1918–22) vice-president (1922–24) and an active worker on several of its committees, was born in St. Paul, Minn. Immediately after graduation from Columbia University in 1896 he entered the employ of the General Electric Company at Schenectady as a student. Shortly thereafter he was transferred to the office of Dr. C. P. Steinmetz to engage in experimental work, tests, and calculations on a number of subjects. For several years he served the Society of Engineers of Eastern New York as treasurer. His contributions to technical literature have been many.

VANNEVAR BUSH

**Dr. Vannevar Bush** (A'15, F'24) since 1923 a member of the faculty of electrical engineering of Massachusetts Institute of Technology, Cambridge, Mass., recently was elevated to his new office of vice-president and dean of engineering, according to appointments announced March 10, 1932. He is a native of Everett, Mass., a graduate of Tufts College (1913), and holds a degree of doctor in engineering from Harvard University and from M. I. T., where his work has been noteworthy in research achievements and contributions to technical education. He has been interested particularly in the design of scientific calculating instruments, and for the development of the product integraph in 1928 was awarded the Levy Medal of the Franklin Institute. Not long since he won recognition for his design of an intricate calculating machine called the differential analyzer, which greatly increases the accuracy and speed of engineering calculations. He is also known for his contributions to the development of vacuum tubes and his investigations in electric power transmission. Under his direction at M. I. T. has been built another instrument known as the network analyzer, a device upon which a power network covering several states may be reproduced accurately and operating characteristics studied under most satisfactory conditions. Important branches of study carried on by Doctor Bush have been those of transients in machines, and dielectric phenomena. His career as a teacher has been no less notable than has his work in research; he has been professor of electrical transmission and for sometime was in charge of graduate study and research in the department. Early in his career he held a position in the test department of the General Electric Company, returning to Tufts College as an instructor in mathematics; from this position he was subsequently advanced to that of assistant professor of electrical engineering. Following the World War during which he did valuable research work on the detection of submarines for a special board of the United States Navy, he was consulting engineer for the American Radio and Research Corporation. He is a director of the Spencer Thermostat Company, Cambridge, Mass., and of Raytheon Incorporated of Newton, Mass. He is a Fellow of the American Academy of Science, and of the American Physical Society; a member of the Society for the Promotion of Engineering Education, and the author of numerous contributions to scientific and engineering literature. The book "Principles of Electrical Engineering" written in joint authorship with Professor W. H. Timbie is probably one of the most widely used books in its field.



H. H. PORTER

**H. Hobart Porter** (A'96, M'12) president of the American Water Works and Electric Company, Incorporated, New York, N. Y., and a Life Member of the Institute, was reelected chairman of the Engineering Foundation at its annual board meeting Feb. 18, 1932. The Foundation is the research organization of the national societies of civil, mechanical, mining and metallurgical, and electrical engineers, with headquarters in the Engineering Societies Building, 33 West 39th Street, New York. Mr. Porter, who is chairman also of the board of the West Penn Electric Company and a director of numerous railroad and public utility enterprises, is a former trustee of Columbia University and a former president of the University Club, New York City. As a member of the firm of Sanderson and Porter, New York, he was engineer of the large hydroelectric development in California of the Stanislaus Electric Power Company, later known as the Sierra and San Francisco Power Company. Power was transmitted 140 miles at 110 kv. to serve the United Railways of San Francisco. This was one of the first 110-kv. transmission lines over so great a distance and involved many original problems. For some years Mr. Porter was one of the consulting engineers for the Interborough Metropolitan Railway Company; his work on many important investigations and as an engineer in charge of large operations was given high commendation, and products of his professional ability have been demonstrated in design and construction developments in many states: in the hydroelectric development for the Inland Empire Railway System, Spokane, Washington, the Twin-branch power plant and transmission system for the Indiana and Michigan Electric Company, South Bend, Ind., the steam power plant and transmission system for the New Hampshire Traction Company, Portsmouth, N. H., two steam power plants for the New Orleans Railway and Light Company, New Orleans, La., and several Connecticut developments of important tramways.

**Gerald Deakin** (A'07, M'13) who was first assistant chief engineer of the International Telephone and Telegraph Company, New York, N. Y., now is in London in the capacity of vice-president and European technical director of the International Standard Electric Corporation.

**Walter Steinkamp** (A'26) previously district manager of the Picker X-Ray Corporation, Buffalo, N. Y., recently became secretary and general manager of James Picker, Inc., and Waite & Bartlett X-Ray Manufacturing Company, both of Cleveland, Ohio.

**H. L. Olesen** (M '27) formerly sales and contact engineer of the Jewell Electrical Instrument Company, Chicago, Ill., now is manager of the radio sales division of the Weston Electrical Instrument Company, Newark, N. J., in charge of the combined radio lines of the Jewell and Weston companies.

**H. N. Hardsog** (A'25) in the past designing engineer with the Narragansett Electric Company, Providence, R. I., on February 8, 1932, became power engineer for the Fall River Light Company, Fall River, Mass., both companies being controlled by the New England Power Engineering and Service Corporation.

**Stuart Wilder** (A'02, M'13) vice-president of the Westchester Lighting Company, Mount Vernon, New York, and a past-president of the Empire State Gas and Electric Company, recently was chosen a vice-president of the Yonkers Electric Light and Power Company. Mr. Wilder's record with the Westchester Lighting Company dates from 1903 when he joined the company as assistant chief engineer of the electrical department.

**G. B. Kirkwood** (A'25) previously district sales manager of the New York, N. Y., sales office of the Pacific Electric Manufacturing Corporation, has been transferred to Los Angeles, Calif., to succeed **L. C. Williams** (A'15, M'26) district manager of the latter office, who has been quite ill of late. Mr. Kirkwood has been engaged in the design and sale of high tension switchgear and protective devices with the Pacific Electric Manufacturing Corporation since 1913, having served successively as shop workman, draftsman, chief draftsman, on costs and estimates, and since 1924 district sales manager. He has been in the San Francisco, Calif., Los Angeles, Calif., Chicago, Ill., Gary, Ind., New York, N. Y., and now the Los Angeles offices of the company.

A. K. MacNaughton (A'21, M'26) who has been with the Georgia Power Company, Atlanta, Ga., as electrical engineer, now has joined the Commonwealth and Southern Corporation, Alabama Power Building, Birmingham, Ala.

J. L. Sherwin (M'30) who has been serving the H. K. Ferguson Company, at Cleveland, Ohio, as electrical engineer, now has gone into business for himself in that city, and will specialize in power plant and industrial engineering reports and design.

A. E. Pope (A'07) vice-president of the New England Power Association, Boston, Mass., has been elected president of the New England Power Company, Worcester, Mass., the association's principal wholesale generating and distribution unit in central New England.

U. N. Halliday (A'28) who has been district sales manager of the Portland territory of the Pacific Electric Manufacturing Corporation, is being transferred to Salt Lake City, Utah, to open a new branch sales office there. His territory will consist of Utah, Idaho, Montana, Wyoming, and Colorado.

E. H. Rosenquest (A'03) president of both the Westchester Lighting Company, Mount Vernon, N. Y., and the Bronx Gas and Electric Company of New York City, and recently elected president of the Yonkers Electric Light and Power Company, was made a director of the United Electric Light and Power Company at a recent meeting of its board.

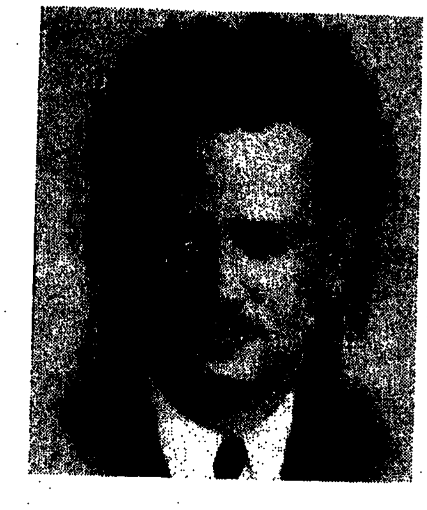
C. H. Cutter (A'28) formerly district sales manager for the Pacific Electric Manufacturing Corporation at Seattle, Wash., has recently been placed in charge of the Portland, Ore., territory for the company. His headquarters will remain at Seattle. Mr. Cutter has been with the Pacific Electrical Manufacturing Corporation since 1921, having served as assistant to the superintendent, purchasing agent, and advertising manager previous to becoming district sales manager.

Kline Gray (A'24) who has been handling the sale of Ward Leonard products for the past seven years with the Westburg Engineering Co., Chicago, Ill., has been appointed Chicago district manager of the Ward Leonard Electric Company. In an effort to better serve this important territory, F. E. Beede, sales engineer of the Ward Leonard company, will be transferred from the factory organization to the Chicago staff. This change has been occasioned by the appointment of P. A. Westburg (A'07, M'16) as Chicago district manager of the Weston Electrical Instrument Corporation.

W. A. DelMar (A'06, F'20) chief engineer of the Habirshaw Cable and Wire Corporation, Yonkers, N. Y., Prof. W. I. Slichter, of Columbia University, W. B. Jackson (A'97, F'13) rate engineer, New York Edison Company, New York City, and W. S. Barstow (A'94, F'12) president of W. S. Barstow and Company, New York, N. Y., have been elected to serve as A.I.E.E. representatives on the library board of the Engineering Societies Library for the year 1932.

J. J. Orr (A'30) plant engineer of A. J. Brandt, Incorporated, Detroit, Mich., has removed to New York City, where he is electrical engineer for the United States Rubber Company. Mr. Orr has specialized in industrial power engineering and supervised the design and installation of the complete electrical system in the General Motors plant at Pontiac, Mich., the American Austin Car Company at Butler, Pa., and the "Amo" Auto Works at Moscow, U. S. S. R.

H. R. Woodrow (A'12, F'23) at a recent election of officers for the Brooklyn Edison Company was made vice-president in charge of electrical operations. He is a native of Rock Rapids, Ia., and a graduate of the University of Illinois (1909). Prior to 1917, Mr. Woodrow was assistant chief electrical engineer of the New York Edison Company with which he has been identified since 1911. As an assistant to Mr. Philip Torchio he was associated with various developments and investigations, and in his appointment as assistant chief electrical engineer he kept closely in touch with the design and operation of all generating and substations of the company. In 1922 he became assistant electrical engineer of the Brooklyn Edison Company, associated with J. C. Parker, recently elected to the presidency, and in this connection demonstrated extraordinary practical judgment, analytical ability and initiative in connection with the electrical design of generating stations, transmission systems, substations, and distribution systems. He has always taken a very active interest in the field of protective devices and for five years served on the Institute's committee on protective devices. He has served also on the A.I.E.E. membership, meetings and papers, standards, and power transmission and distribution committees, the last of which he was chairman 1928–30; at present he is a director and serving also on the publication committee. Mr. Woodrow was identified in a consulting capacity in the design of the Trenton Falls and Washington Street station at Dayton, Ohio, the Williamsburg station of the Brooklyn Rapid Transit Company, and the government plant at Nitro, Va. His transfer to the grade of Fellow endorsed by Benjamin G. Lamme included the statement, "I have been in direct contact with Mr. Woodrow's work for many years in engineering problems requiring advanced knowledge of electrical theory and practise in the application of electrical apparatus, and have found him a man of very great knowledge and ability."



H. R. WOODROW

G. L. KNIGHT

G. L. Knight (A'11, F'17) mechanical engineer of the Brooklyn Edison Company, Brooklyn, N. Y., for many years, and prior to his appointment as such, design engineer for that company, was chosen by recent election to be its vice-president in charge of mechanical operations. Born at Haddonfield, N. J., Mr. Knight was graduated from Drexel Institute in both mechanic arts (1898) and electrical engineering (1900). In 1902 he was manager of the Walker Electric Company of Philadelphia, Pa. For two years he was chief draftsman of the New York Edison Company prior to his transfer to the Brooklyn Edison Company in 1905 in like capacity. In 1908 he was made designing engineer, the position he occupied until 1924 when he became mechanical engineer. He has done no inconsiderable special electrical, mechanical, and civil engineering work in connection with the construction of large central stations, from the laying of their heavy foundations and condensing tunnels straight through to the completion of stations ready to operate, and the complete design and construction of substations, storage yards, and office buildings. His committee work with the Institute has been abundant; he has served on the following committees: standards 1914–25; board of examiners, 1922–4, 1928–9; finance, 1922–8; executive, 1923–8; headquarters, 1923–8; coordination of Institute activities, 1923–6, 1927–8; Edison Medal, 1926–8; meetings and papers *ex-officio* 1927–8; and power generation, 1927–9. He was a member of the U.S. national committee of the International Electrotechnical Committee, 1923–6; and a member of the board of trustees of the United Engineering Trustees, 1926–31. Besides his committee work, Mr. Knight has served the Institute as a manager 1922–6, and a vice-president, 1926–8.

Harry B. Smith (A'28) who has been serving the Northern Electrotype Company of Detroit, Michigan, as mechanical engineer, has been made a vice-president of the American Electrotype Company, also in Detroit.

H. S. Falk (A'08) vice-president and general works manager of the Falk Corporation of Milwaukee, Wis., was elected a director of the Heil Company of that city at a recent meeting of the board.

H. M. Brinckerhoff (M'26) of the firm of Parsons, Klapp, Brinckerhoff and Douglas, of New York, N. Y., has been appointed a member of the city plan commission of Englewood, N. J.

R. C. Young (A'29) previously district manager for the Kuhlman Electric Company, Atlanta, Ga., has been transferred to the Chicago, Ill., territory of the company where he will continue as district manager.

F. J. Cornford (A'23) who was construction superintendent for the Ohio Power Company, Philo, Ohio, now is construction engineer for the Scranton Electric Company at Pittston, Pa.

D. C. Harker (A'27) who was a general engineer for the Westinghouse Electric and Manufacturing Company, Detroit, Mich., now has joined the Hudson Motor Car Company in that city as engineer.

G. J. Lexa (A'20) electrical engineer, Harnischfeger Corporation, Milwaukee, Wis., recently changed his affiliations and became electrical engineer of the Lakeside Bridge and Steel Company of that city.

A. E. Waller (A'12, F'21) priorly associated with the General Cable Corporation, now has joined the Sundh Electric Company of Newark, New Jersey, as sales engineer.

P. J. Ost (M'23) who served the City of San Francisco as its chief electrical engineer now has taken a similar position with the Public Utilities Commission of San Francisco, Calif.

F. W. Willis (A'04, F'19) who served as local Honorary Secretary of the Institute for India from 1925 to 1930, has retired from active service in India and is now residing in Auckland, New Zealand.

# Obituary

Frank George Baum (A'99, F'14) consulting engineer, vice-president of the Institute 1906–8, and a pioneer in hydroelectric and transmission developments on the Pacific Coast, died at Redding, California, his place of residence, March 14, 1932. He was 61 years of age. Mr. Baum was born at Ste. Genevieve, Missouri; his batchelors degree in electrical engineering was conferred upon him by Stanford University at the time of his graduation in 1898. In 1899 he received his E.E. degree at the completion of a year spent at the same institution as assistant in electrical engineering. To bring the consumer and producer together is a most interesting economic problem of any age, and this was the work which Mr. Baum made the keynote of his remarkable career. He was employed first by the Standard Electric Company of California. Blessed with high inventive genius, he was enabled to solve many problems in the production and transmission of power. In the Piedmont station (Calif.) he was the originator of the compounding of synchronous motor-generator sets, whereby the compounding of the exciters was taken from the shunt on the busbar of the railway load, changing the power factor of the motors and keeping the potential of the substation nearly normal. This was in line with his much later invention, the synchronizing condenser and regulator, announced in 1927, a device which solved the problem of economical transmission of large amounts of electrical power over distances of several hundred miles, dividing the lines into sections of from 100 to 200 miles linked by rotary regulators or condensers, each transmitting the current onward with small losses. W. S. Rugg (A'02, M'13) vice-president of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., by which the patents were acquired is quoted as asserting that "by means of it the capacity of a given line can be increased 75 per cent at a cost not exceeding 20 per cent of the original cost of the line, making possible the economical transmission of power from distant waterfalls and ultimately making possible for sparsely settled outlying districts and farms almost anywhere in the United States a supply of electric power." From 1900 to 1902 he was instructor in electrical engineering at Stanford University at the same time doing special work in electrical transmission for the Bay Counties Power Company and others. He then became an electrical engineer of the California Gas and Electric Corporation, and from 1907 on practised consulting engineering with special reference to hydroelectric developments. The conception and much of the engineering outline of the Pit River power developments for the Pacific Gas and Electric Company were attributable to Mr. Baum's foresight and appreciation of possibilities. He designed Hat Creek Nos. 1 and 2, Pit River No. 1, the 220,000-volt Pit transmission line, and the great Vaca substation at the receiving end. His work during the years 1926–8 was developing insulators and regulations systems outlined in his paper "Voltage Regulations and Insulation of Large-power Long-Distance Transmission System" for which he received the Institute's 1921 yearly transmission prize. For the betterment of social conditions Mr. Baum believed firmly in the linking of business enterprise with scientific thinking, his expressed thought being that "the best control of a utility is that which develops an eagerness and ability on the part of the company to furnish service and an equal eagerness and ability on the part of the consumer to purchase the service. He was the author of the books "Alternating Current Transformer" and "Atlas of U. S. A. Electric Power Industry." Several years were spent studying the European electrical power industry, and he completed a voluminous report on the enlargement and extension of one of Germany's largest electric utilities. His international reputation took him into both France and Germany as a consultant for power concerns, and upon his return to California he established extensive laboratories in the mountains of the northern part of the state for a further study of electrical engineering.

Engelhardt Wilboren Holst (A'05) consulting engineer with offices in Boston, Mass., died at his home in Concord, N. H., February 1, 1932. He was 61 years of age. A native of Christiania, Norway, Mr. Holst received his early technical training there, graduating with an M.E. degree. He came to the United States and engaged with the General Electric Company of Chicago in the summer of 1895, starting with the General Electric test course and subsequently being promoted to the superintendency of the company's repair shop. Two and a half years were spent with the company's Canadian office and one year in travel. In 1905 he took the position of superintendent of equipment for the B & N and Old Colony Street Railway Company, Boston, Mass., and later assumed like duties with the Bay State Railway Company, also of Boston. The Boston consulting engineering practise in which he was engaged at the time of his death was established in 1920.

Isabelle Conkling Conlin (nee Williams) (A'21) of Hempstead, N. Y., died January 23, 1932; she had been ill for several years. Born in Brooklyn April 6, 1894, Mrs. Conlin received her early education in the New York public schools. In 1917 she was graduated from Barnard College, the Columbia University School for women in New York City. She immediately became associated with the Western Electric Company as engineering assistant in the physical laboratory and in 1920 was made laboratory engineer supervising an electrical measurement group, and establishing for herself a creditable record of achievement and capability.

Jeremiah Joseph Kennedy (A'00, M'02) consulting engineer, Brooklyn, N. Y., died February 15, 1932. He was born in Philadelphia, Pa., October 22, 1864, and was educated in the private schools of that city. His technical education also was obtained under private tutelage and included chemistry, and civil, mechanical, and electrical engineering, this last subject receiving the major part of his attention. The first of the year 1882 he joined the Norfolk and Western railroad as a rodman, returning in the fall of that year to study higher mathematics and civil engineering.

The following June he became principal assistant to General Russell Thayer, in civil engineering; for another year, still pursuing his studies, he spent considerable time visiting mines, various works in operation, and inspecting important structures. July 1885, he was given charge of various field surveys in Pennsylvania and Virginia, and in August became chief engineer of the Lynchburg Iron Company operating iron mines and constructing railroads. During the major part of 1886 he served as principal assistant to General Russell Thayer, but in November 1888, he turned his attention to electrical engineering and six years later became principal assistant engineer to J. G. White, president of J. G. White & Company of New York and Baltimore; three years later he was made chief engineer. With this company his work included cable and electric railway construction; the design and construction of subways in Baltimore; design, construction, and operation of electric light and power plants; the design and construction of substations for the Toledo and Detroit railway, and for the Niagara Falls-Buffalo transmission line. Previous to this he was for two years chief engineer of Atlantic Highlands, Red Bank, and Long Branch Electric Railway and for over a year he filled the position of chief engineer and superintendent of the Borough of Manhattan Electric Company, New York City, for the purpose of reconstructing and reorganizing its plants, and subsequently to plan and install extensions; it was while filling these positions Mr. Kennedy secured his permanent position as chief engineer of the J. G. White and Company. Mr. Kennedy was one of the first engineers to appreciate the advisability of making parts and flywheels of engines used in parallel operation of such weight that they would have no tendency to vibrate in harmony with the electrical oscillations. His attack of any engineering problem was energetic and intelligent and he was an enthusiastic and indefatigable worker. Among his other achievements in the line of electrical design and construction were the Detroit and Lake Orion Railway, Detroit, Mich., the power station at Perth, West Australia, and the design of a proposed central station for the Third Avenue railway of New York City.

# Local Meetings

## Past Section Meetings

**Atlanta**

Audible Light, by John B. Taylor, Genl. Elec. Co. Demonstrations. Feb. 15. Att. 850.

**Chicago**

Electric Motor Control, by G. C. Wilms, Bradley Mfg. Co. Joint meeting with Western Soc. of Engrs. Feb. 15. Att. 178.

**Cincinnati**

Electric Shock, by Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres. A.I.E.E. Dinner. Feb. 25. Att. 85.

**Cleveland**

Demonstration and lecture by S. P. Grace, asst. vice-pres., Bell Telephone Labs., Inc. Joint meeting with Advertising Club, Chamber of Commerce, Cleveland Engg. Soc., and Elec. League. Feb. 3–4. Att. 5,000.

Field Studies of Lightning Protection on Distribution Circuits, by K. B. McEachron, Genl. Elec. Co. Feb. 18. Att. 107.

**Dallas**

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Feb. 26. Att. 127.

Construction Progress at the Hoover Dam, by S. O. Harper, U.S. Bureau of Reclamation. Demonstrations. Dinner. Feb. 10. Att. 60.

**Detroit-Ann Arbor**

Fundamental Physical and Psychological Aspects of Television, by J. O. Perrine, Am. Tel. & Tel. Co. Demonstrations. Joint meeting with Detroit Engg. Soc. Feb. 16. Att. 650.

**Erie**

History and Development of Motor Driven Electric Clocks, by Alvan Fisher, Warren Telechron Co. Feb. 16. Att. 100.

**Fort Wayne**

Radio Interference, by Arthur B. Smith, Assoc. Elec. Labs. Discussion. Feb. 11. Att. 90.

**Houston**

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Dinner. Feb. 24. Att. 85.

**Indianapolis-Lafayette**

Electrons at Work and at Play, by Dr. Phillips Thomas, Westinghouse Elec. & Mfg. Co. Demonstrations. Feb. 10. Att. 340.

**Ithaca**

Protection of Distribution Circuits and Apparatus, by B. B. McEachron, Genl. Elec. Co. Feb. 19. Att. 124.

**Kansas City**

Light and Architecture, by A. L. Powell, Genl. Elec. Co. Dec. 28. Att. 110.

Control of Smoke Nuisance in Cities, by A. S. Longsdorf, Wash. Univ. Joint meeting with A.S.M.E. Sec. Jan. 15. Att. 85.

**Los Angeles**

Overseas Telephone Services of the Bell System, by W. H. Harrison, Am. Tel. & Tel. Co. Demonstrations. Feb. 9. Att. 106.

**Louisville**

Lightning—Recent Investigations and Findings, by F. W. Peek, Jr., Genl. Elec. Co. Demonstrations. Feb. 19. Att. 169.

**Lynn**

America Steps Ahead With the Akron, by R. H. Smith, M.I.T. Movies. Feb. 10. Att. 1,054.

Mercury Vapor Turbines, by L. A. Sheldom and B. P. Coulson, Genl. Elec. Co. Feb. 24. Att. 500.

**Memphis**

Development of Vocational Guidance, by J. L. Highsaw, Memphis Tech. High Sch. Feb. 9. Att. 35.

**Mexico**

Some Recent Developments and Trends in Electrical Machinery and Apparatus, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Demonstrations. Feb. 17. Att. 70.

Banquet. Feb. 18. Att. 58.

**Minnesota**

Research Work in Laboratory Developments, by H. D. Sanborn, Genl. Elec. Co.; The Challenge to the American Business Man, by J. B. Chapple, Ashland Daily Press. These talks were given before the convention of the Minnesota Federation of Architectural and Engg. Societies. Feb. 26–7. Att. 100.

**Montana**

Recent Developments in the Electrical Field, by A. D. Atewart, Westinghouse Elec. & Mfg. Co. Discussion. Feb. 18. Att. 43.

Dean H. V. Carpenter, State Col. of Wash., vice-pres. A.I.E.E., gave a report of the winter convention held in New York. Discussion. Feb. 25. Att. 30.

**New York**

Marine Engineering and the American Merchant Marine, by Arthur M. Tode, pres., Propeller Clubs of the U.S. (Transportation group.) Feb. 10. Att. 275.

Characteristics and Protection Requirements of the Low-Voltage A.C. Network, by C. W. Pickells, N. Y., and Queens Elec. Lt. & Pwr. Co., A. Pinto, Otis Elevator Co., L. A. Nettleton, Bklyn. Edison Co. (Power Group.) Feb. 18. Att. 250.

The New Music of Electrical Oscillations, by Benjamin Miessner, Capt. Richard Ranger, and Prof. Leon Theremin. Feb. 26. Att. 875.

Recent Investigations of New York City Smoke, by E. E. Free, N. Y. Univ. March 8. Att. 75.

**Oklahoma City**

Noise Induction Between Power Transmission and Telephone Circuits, by E. B. Jennings, Southwestern Bell Tel. Co., and C. E. Bathe, Oklahoma Gas & Elec. Co. Demonstrations. Jan. 25. Att. 115.

**Philadelphia**

Electron Tubes in Industry, by E. H. Alexander, Genl. Elec. Co. Demonstrations. Jan. 11. Att. 150.

Ship Stabilization by Electrically Controlled Mechanical Devices, by Nicholas Minorsky, Univ. of Pa. Feb. 8. Att. 180.

**Pittsburgh**

The Westinghouse Section Mercury Arc Rectifier, by A. L. Atherton, J. H. Cox, D. C. West, H. Speight, A. J. Maslin, R. R. Longwell, and J. Slepian. Joint meeting with Engrs. Soc. of Western Pa., Feb. 9. Att. 453.

An Outdoor Mercury Boiler Power Station, by A. R. Smith, Genl. Elec. Co. Dinner. Joint meeting with Engrs. Soc. of Western Pa., March 8. Att. 174.

**Pittsfield**

Men Made Island to Speed Ocean Flying, by E. R. Armstrong, Armstrong Seadrome Corp. Feb. 16. Att. 300.

Famous Women Spies and Their Methods, by Maj. Thomas Coulson. Dinner. March 1. Att. 1,450.

**Portland**

Motion pictures describing cable manufacture and short talks on telephone transmission. Feb. 23. Att. 75.

**St. Louis**

The World of Electrons, by Larry Hawkins, Genl. Elec. Co. Feb. 16. Att. 1,600.

**San Antonio**

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Feb. 23. Att. 99.

**San Francisco**

Overseas Radio Telephone Servce of the Bell System, by W. H. Harrison, Am. Tel & Tel. Co. Joint meeting with I.R.E. and Signal Corps Assn. Feb. 12. Att. 450.

**Schenectady**

Vertical Transportation in Buildings, by

Bassett Jones, Meyer, Strong, and Jones. Joint meeting with A.S.M.E. Jan. 21. Att. 125.

Air Conditioning in Buildings, by A. R. Stevenson, Gen. Elec. Co. Joint meeting with A.S.M.E. Sec. Feb. 4. Att. 130.

The Great Ice Age in North America, by K. F. Mather, Harvard Univ. Joint meeting with A.S.M.E. Sec. Feb. 18. Att. 425.

**Seattle**

Segregation of Hydroelectric Power Costs, by W. S. McCrea, Jr.; Generator Voltage Regulators, by K. L. Howe; Reflected Voltage Waves in Single Phase Induction Motors, by D. C. Moore; Residential Underground Distribution System, by Wallace Quistorff. W. S. McCrea awarded prize of $25 for presentation of best paper. Jan. 19. Att. 75.

**Sharon**

Modern Marvels, by C. K. Lee, Westinghouse Elec. & Mfg. Co. Feb. 16. Att. 135.

**Spokane**

Institute Affairs and Report on the Winter Convention, by Dean H. V. Carpenter, State Col. of Wash., vice-pres., A.I.E.E. Feb. 26. Att. 21.

**Toledo**

Executive committee meeting. Feb. 9. Att. 9.

Protective Relays, by J. H. Hunt, Toledo Edison Co.; Modern Circuit Interrupters, by J. Slepian, Westinghouse Elec. & Mfg. Co. Demonstrations. Discussion. Feb. 19. Att. 80.

**Toronto**

Non-Resonating Transformers, by K. K. Palueff, Genl. Elec. Co. Demonstrations. Feb. 11. Att. 114.

Automatic Frequency Control, by J. B. McClure, Genl. Elec. Co. Joint meeting with Niagara Frontier Sec. and Engg. Inst. of Canada. Feb. 19. Att. 151.

Some Physical Characteristics of Speech and Music, by Harvey Fletcher, Bell Tel. Labs., Inc. Demonstrations. Feb. 26. Att. 350.

**Urbana**

Modern High Power Transmission Antenna, by Prof. H. A. Brown, Univ. of Ill. March 2. Att. 35.

**Utah**

What Men See With, by A. S. Bennion, Utah Pwr. & Lt. Co. Dinner. Feb. 8. Att. 70.

**Washington**

Some Thoughts on Waves, by O. B. Blackwell, Am. Tel & Tel. Co. Dinner. Feb. 9. Att. 130.

## Future Section Meetings

**Akron**

April 12—The Electrical Industry and Some Problems of the Institute, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Movies.

May 10—Annual banquet and ladies' night. Human Engineering, by Dean Fred E. Ayer, Univ. of Akron. Movies.

**Baltimore**

April 15—Subject to be announced. Speakers from Western Electric Co.

May 20—Speaker: Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres. A.I.E.E.

**Cleveland**

April 21—Electric Refrigeration and Domestic Air Conditioning, by W. M. Timmerman, Genl. Elec. Co.

May 19—Subject and speaker to be announced.

**Dallas**

April 11—The Coordination of Line and Station Design for Lightning Surge Conditions, by A. O. Austin, Ohio Brass Co.

**Detroit-Ann Arbor**

April 19—Commercial Metering of Electric Energy, by A. S. Albright, Detroit Edison Co.

May 17—House of Magic, by Oliver Ajer, Genl. Elec. Co.

**Louisville**

April 15—Inspection trip to Bowman Field Airport. Fundamentals of Plane Construction and Flight, by A. W. Lee, Louisville Gas & Elec. Co.

May 13—Dial Telephone Equipment in Louisville. Speaker from Southern Bell Tel. & Tel. Co.

**New York**

April 15—Final meeting of power group; general subject: regulation of power flow between interconnected systems. General Problems of Interconnection, H. L. Melvin, Electric Bond and Share Company; Automatic Control of Frequency and Load, J. B. McClure, Genl. Elec. Co. Election of power group officers. Meeting to be held in Engineering Societies Building at 7:30 p.m.

**Pittsburgh**

April 12—Television. Demonstrations. Joint meeting with I.R.E.

May 10—Annual banquet and ladies' night.

**Seattle**

April 19—Joint meeting with Student Branch at Univ. of Wash.

May 17—Address by L. Sapovi, Hooker Electro-Chemical Co.

**Spokane**

April 22—New Developments in Oil Circuit Breakers, by J. F. Spease, Genl. Elec. Co.

May 27—Annual dinner meeting. History of the Electrical Development of the Inland Empire, by John B. Fisken. Election of officers.

**Toledo**

April 15—Problems in the Design of Large Turbo-Alternators, by S. H. Mortensen, Allis-Chalmers Co.; Application of Electricity in Industry, by R. E. Paxton, Toledo Edison Co.

**Vancouver**

April 4—Switchgear, by W. D. Robertson, Canadian Genl. Elec. Co., Ltd.

May 2—Open.

May 21—Annual outing to the Baker River Plant of the Puget Sound Pwr. & Lt. Co.

## Past Branch Meetings

**University of Akron**

Biography of Alexander Graham Bell, by R. I. Felver, student; Baffle Boards and Their Relation to Modern Loudspeakers, by Sol. Leibowitz, student. Demonstrations. Feb. 24. Att. 9.

**Alabama Polytechnic Institute**

Electrification of the Norfolk and Western Railway, by F. N. Williams, student; Telephone Systems, by D. P. Johnson, student. Feb. 18. Att. 10.

Manufacture of Cast Iron Pipe by the Mono-Cast Centrifugal Process, by S. D. Moxley, Am. Cast Iron Pipe Co. Joint meeting with A.S.M.E. Feb. 2. Att. 45.

**University of Arkansas**

Non Sine Waves, by H. G. Thomasson, student; Vectors, by E. E. Ray, student; Harmonic Analizers, by J. G. Lewis, student. Feb. 3. Att. 35.

Electric Shovels, by Robert Vining, student; Brushes, by E. E. Boreland, student; Automatic Stops for Elevators, by F. L. McDonald, student. Feb. 15. Att. 30.

**Armour Institute of Technology**

Building Networks, by E. E. Chilberg, Genl. Elec. Co. Feb. 19. Att. 30.

**University of British Columbia**

Automatic Telephony, by J. W. McRae, student. Discussion of transmission systems. Feb. 9. Att. 14.

The C.G.E. Test Course, by S. D. Scott, student; The Automatic Switchboard Installed for the Powell River Pulp and Paper Co., by H. E. Woodland, student. Film—"The Transportation Problem." Feb. 23. Att. 19.

Film—"Electrification of the Mexicana Railway." Feb. 24. Att. 100.

**Brooklyn Polytechnic Institute**

The Pianoforte or Engineering Applied to the Art of Music, by Wm. B. White, Am. Steel & Wire Co. Demonstrations. Refreshments. Jan. 14. Att. 200.

**Bucknell University**

Lighting and Its Relation to Industries, by George Heinish, student. Feb. 11. Att. 12.

**University of California**

The Development and Application of Vacuum Tubes, by A. W. Copley, Westinghouse Elec. & Mfg. Co., vice-pres. A.I.E.E. Banquet. Feb. 19. Att. 46.

Engineering Observations on a Recent Trip East, by W. C. Smith, Genl. Elec. Co. Feb. 24. Att. 35.

**Case School of Applied Science**

The Research Attitude, by Prof. T. D. Owens; Safety Devices on Street Cars, by J. C. Elder, student; X-Ray Protective Devices, by W. J. Cherney, student. Feb. 17. Att. 51.

W. J. Cherney elected chairman. March 4. Att. 43.

**Catholic University of America**

Electricity and the Telephone, by Mr. Gioffre, Chesapeake & Potomac Tel. Co. Refreshments. Feb. 24. Att. 3.

**University of Cincinnati**

Elevator Motors and Control, by A. J. Liebenberg, Warner Elev. Co. Feb. 17. Att. 40.

**Clemson Agricultural College**

Photoelectric Tubes, by Prof. F. T. Tingley; The Present Practises in Insulated Power Cables, by W. G. Wallenberg, student. March 3. Att. 20.

**University of Colorado**

Films—"Speeding up Our Deep Sea Cables" and "Pictures by Wire." Refreshments. Feb. 10. Att. 55.

New Ideas for High Voltage Circuit Breakers, by C. A. Church and N. R. Damon. Slides. Feb. 24. Att. 30.

**Cooper Union**

Engineering Aspects of the Soviet Five Year Plan, by W. N. Polakov. Feb. 4. Att. 70.

**University of Denver**

Films—"Mazda Lamps," "Electric Ships," "Liquid Air," and "A Visit to the General Electric Factory With Earl Carroll." Feb. 18. Att. 84.

**University of Detroit**

Construction and Application of Storage Batteries, by W. C. Leingang, Elec. Stor. Bat. Co. Film—"The Electric Ship." March 2. Att. 45.

**Duke University**

Mercury Arc Rectifiers, by Mr. Creekmore, student. Discussion. Feb. 11. Att. 13.

Illumination and Neon Tubes, by Mr. Garrett, student; Short Wave Receiving Circuits, by Mr. Flack, student. Feb. 25. Att. 13.

**University of Florida**

Amateur Radio, by G. W. Haug, student; The Kennelly-Heaviside Layer and Methods for Determining Its Height, by D. G. Beck. March 7. Att. 25.

**Georgia School of Technology**

Films—"Automatic Arc Welding" and "Busy Body." Feb. 16. Att. 60.

**University of Illinois**

Discussion of plans for the elec. engg. show. Feb. 17. Att. 100.

**Iowa State College**

Film—"The Life of Edison." Feb. 10. Att. 50.

**University of Iowa**

Films—"General Electrical Icing Unit." Election of officers as follows: H. A. Peterson, chmn.; L. E. Travis, vice-chmn.; J. F. Kapinos, secy-treas. Feb. 3. Att. 44.

Discussion. Feb. 10. Att. 24.

Electrical Relays, by M. J. Larsen, student. Feb. 17. Att. 30.

New Radio Air Cell a Battery, by L. F. Grizel, student; The Growth of the University Radio Station, by R. E. Griffin, student; Electricity in the Moffat Tunnel, by D. G. Fritz, student; Television, by E. C. Dunn, student. Feb. 24. Att. 38.

### Kansas State College

Election of officers. Feb. 4.

Talk by G. W. Wood, Frigidaire Co. Feb. 18. (Afternoon meeting.)

Russia, by J. C. Bradley. Feb. 18. (Evening meeting.)

### University of Kansas

Cooperative Education, by Prof. D. C. Jackson, Jr., counselor. Feb. 18. Att. 36.

The Making of a Life, by R. A. Schwegler, dean, school of education. Films—"Far Speaking" and "Voices Across the Sea." March 3. Att. 54.

### Lafayette College

Welding, by A. S. Cumberland, Ingersoll-Rand Co. Illus. Joint meeting with A.S.M.E. and A.S.C.E. branches. Feb. 26. Att. 50.

### Louisiana State Univeristy

The Wyman Dam Hydroelectric Project, by E. E. Frenzel, student. Feb. 18. Att. 19.

### University of Louisville

Advantages of Governmental Control, by J. Groves, student; Advantages of Private Ownership, by J. Morris, student. Feb. 12. Att. 11.

### University of Maine

Planning a Power System, by H. W. Coffin, Bangor Hydroelec. Co. Feb. 25. Att. 23.

### Marquette University

Magnetic Testing, by Prof J. F. H. Douglas, assisted by Messrs. Trimborn, Dernbach, Hallbach, and Van Peterson, students. Feb. 4. Att. 20.

### Massachusetts Institute of Technology

Inspection trip through the L Street generating station of the Edison Elec. Ill. Co. Feb. 19. Att. 15.

The Thyratron Tube, by H. M. Wagner, student. Dinner. Feb. 25. Att. 65.

### Michigan College of Mining and Technology

Industrial Applications of Vacuum Tubes, by R. E. Welton, Gen. Elec. Co. Films "Automatic Substation for Mining and Industrial Service" and "Big Deeds." Feb. 11. Att. 36.

### Michigan State College

The Development of the Vacuum Tube, by W. A. Stelzer, student. Feb. 23. Att. 11.

Methods of Fixing Light and Power Rates, by Mr. Carolyn, Consumers Pwr. Co. March 8. Att. 14.

### School of Engineering of Milwaukee

Organization, Purpose, Duties, and Operation of the Milwaukee Fire Department, by Mr. Lippold, asst. fire cf. Feb. 10. Att. 46.

### University of Minnesota

Inspection trip through the Elec. Mchy. Mfg. Co. Feb. 18. Att. 65.

### University of Missouri

Ultra High Frequency Oscillations, by C. Thorne and L. Smarr, students; Television, by H. Leibovich and L. Buell, students. Feb. 17. Att. 18.

Adventures in Science, by L. A. Hawkins, Genl. Elec. Co. Joint meeting with Sigma Xi. Feb. 27. Att. 263.

### Montana State College

The Swope Plan, by A. J. Hill, student; A Modern Laundry, by C. G. Anderson, student; Electric Arc Welding in Mines, by E. Hughes, student; Development of Transformers, by R. MacDonald; The Origin of the Electrical Science, by Wm. H. Scheele. Jan. 28. Att. 103.

### University of Nebraska

Film—"Power Transformers." Feb. 17. Att. 22.

Demonstration of thyratron tubes by L. W. Cook and P. Ehrenhard, students. March 2. Att. 34.

### Newark College of Engineering

Photoelectric Cells, by J. Wier, student; Application of Photoelectric Cells, by W. Amon, student; Thyratron Inverter, by W. R. McLaughlin, student. Feb. 29. Att. 22.

### University of New Hampshire

Film—"Something About Switchboards." Jan. 9. Att. 28.

A New Warning Beacon Which Utilizes the Vacuum Tube, by A. Philbrick, student; Convict Labor in Highway Construction, by H. W. Feindel, student. Jan. 16. Att. 27.

The Solution of Unbalanced Faults on Transmission Lines by the Method of Symmetrical Coordinates, by H. R. Stewart, Westinghouse Elec. & Mfg. Co. Jan. 20. Att. 78.

Discussion. Feb. 6. Att. 24.

The Future Engineer, by O. K. Reed, student; The Electron Tube in Industry, by H. W. Hunt, student. Feb. 13. Att. 21.

Discussion of plans for spring inspection trip. Feb. 20. Att. 22.

Discussion. Feb. 27. Att. 26.

Predetermined Counter and Its Uses, by J. Prentice, student; Diesel Electric Drives Used on Tramp Steamers, by R. D. Ives, student. March 5. Att. 21.

### University of New Mexico

Discussion of plans for engineers' day. Feb. 17. Att 10.

Engineering Achievements of the General Electric Co. During 1931, by Martin Zirhut, student. Feb. 25. Att. 17.

### College of the City of New York

Discussion. Feb. 18. Att. 18.

The Tools of Modern Warfare, by Maj. Carl de Zafra, U.S. Army. Feb. 25. Att. 44.

Some Recent Developments in Electrical Communication, by R. D. Parker, Am. Tel. & Tel. Co. Demonstrated. March 3. Att. 40.

### New York University

Quasi Optical Waves, by E. H. Osterland, student; Labor Unions, by W. Rubsamen, student. Feb. 16. Att. 12.

Amateur Radio Station Equipment, by J. Mantone, student; Measurement of the Moisture Content of Wood by Electrical Methods, by A. W. Lebert, student. Feb. 23. Att. 13.

The Present Patent Situation, by L. C. Dinnar, student; Quartz Crystal Oscillators, by H. C. Fleming, student. March 1. Att. 13.

The Development of the Use of Electricity at Sea, by J. P. Munroe, student; The Inductive Compensating Generator, by C. J. Dunn, student. March 8. Att. 13.

### North Carolina State College

Neon Tubes, by K. L. Ponzer, student; Late Electrical Developments, by C. M. Smith, student; Amateur Radio Transmission and Reception, by D. A. Worsley, student; Electricity in Syria, by Joseph Salem, student. Jan. 26. Att. 31.

Film—"General Electric Enameling Furnace." Feb. 9. Att. 21.

### North Dakota State College

Recent Developments in Modern Illumination, by O. P. Cleaver, Westinghouse Elec. & Mfg. Co. Feb. 5. Att. 93.

Impressions of Engineering, by Foster Buck. Film "The Story of the Glass Bottle." Joint meeting with A.S.M.E. and A.S.C.E. branches. Feb. 18. Att. 66.

### University of North Dakota

Engineering Developments in 1931, by L. A. Myrand, Westinghouse Elec. & Mfg. Co. Film—"Dynamic America." Feb. 17. Att. 32.

Television, by O. A. Bondeled, North Western Bell Tel. Co. March 2. Att. 28.

### Northeastern University

The Cathode Ray Oscillograph, by H. W. Samson, Genl. Radio Co. Demonstrations. Feb. 17. Att. 82.

### University of Notre Dame

Motor Control, by C. J. Maloney, Cutler Hammer Mfg. Co. Demonstrations. Incidents in the Development of Electric Traction, by P. McCaffrey, student. John Scanlan, student, presented the new reviews. Feb. 15. Att. 77.

Manufacture of A Radio Tube, by W. S. Brian, Grigsby-Grunow Co.; Development of the Incandescent Lamp, by C. Roberts, student; Sound on Filament, by L. Simmons, student; Engineering Culture, by H. E. Ball, student. John Scanlan, student, presented the usual current review. Feb. 29. Att. 71.

### Ohio Northern University

A.C. Welding, Conception of the Electron Theory, and Methods of Locating Grounds on Power Lines, by O. R. Jacobs, student. Jan. 14. Att. 19.

Home Lighting, by L. Berger, student. Demonstrations. Jan. 28. Att. 9.

### Ohio University

Film—"From Mine to Consumer." H. B. McCrone, Am. Brass Co., explained the film. Feb. 17. Att. 55.

Edison Three Wire Transmission Lines, by R. H. Lloyd, student. March 9. Att. 13.

### Oregon State College

Life of Edison, by B. Blazen, student. Short Wave Radio Transmission to Hawaii, by R. W. Deardork, Pac. Tel. & Tel Co. Demonstrations. Feb. 11. Att. 57.

### Pennsylvania State College

The Recent Tube Developments of Interest to Industry, by H. L. Saxton. Feb. 19. Att. 75.

### University of Pittsburgh

Electrification of Railroads, by C. E. Coleman, student; Life of Faraday, by W. Piercy, student. Jan. 14. Att. 128.

Operation of Automatic Train Signaling, by H. E. Kallenburger, Union Switch and Signal Co. Demonstrations. Jan. 19. Att. 87.

Industrial Application of Vacuum Tubes, by R. Hansen, student. Feb. 4. Att. 127.

Code System of Continuous Train Control, by O. L. Zimmerman, student; Methods of Rolling Steel Plates, by M. Zofchak, student. Feb. 11. Att. 120.

Photoelectric Cells, by Wm. Dambart, student. Feb. 18. Att. 126.

Mercury Arc Rectifiers, by Mr. Atherton, Westinghouse Elec. & Mfg. Co. Feb. 25. Att. 126.

### Pratt Institute

Film—"Manufacture of Electric Cables." Feb. 4. Att. 25.

Electricity and the Pipe Organ, by D. Enslee, student. Feb. 17. Att. 20.

### Princeton University

Film—"Electrical Measuring Instruments." Feb. 11. Att. 8.

### Purdue Univ.

Einstein's Theory, by R. J. Kryter, Prest-O-Lite Stor. Bat. Co. Feb. 16. Att. 508.

### Rhode Island State College

Television, by Messrs. Daly and Downes, students. Feb. 25. Att. 12.

### Rice Institute

Election of Officers as follows: E. A. Turner, Jr. chairman; G. R. Adams, vice-chairman; J. E. Reed, secy.; R. C. Bearmann, treas. Feb. 17. Att. 11.

### Rose Polytechnic Institute

History and Manufacture of Cables, by F. E. Calvert, Gen. Elec. Co. March 3. Att. 36.

### Rutgers University

The Twin Function of Engineering, by J. Rudnitsky, student. Feb. 16. Att. 17.

Sweep Circuits of Cathode Ray Oscilloscope, by B. Schmurak, student. Feb. 23. Att. 20.

### University of South Carolina

Television Scanning by Means of Cathode Ray Tubes, by R. M. Warren, Jr., student; Unloading of Grain Cars, by J. T. Lyman, student; Dial Type Thermotel, by E. C. Willis, student. March 10. Att. 55.

### South Dakota State School of Mines

Combustion, by Chuck Laws, Montana-Dakota Pwr. Co. Feb. 25. Att. 28.

### University of South Dakota

Film—"The Single Ridge." Feb. 16. Att. 35

### University of Southern California

Discussion. Feb. 3. Att. 15.

Discussion and moving pictures. Feb. 10. Att. 31.

### Southern Methodist University

Underground Distribution Network System of Dallas Power & Light Co., by M. M. Lehmberg, student. Feb. 16. Att. 12.

Luncheon. Feb. 24. Att. 11.

### Stanford University

Radio Broadcasting Station at Sanford and Its Equipment, by P. F. Byrne, student; High Voltage Transmission, by Prof. J. S. Carroll, counselor. Jan. 14. Att. 28.

Inspection trip through the studios of the Natl. Broadcasting Co., Inc. Jan. 30. Att. 40.

Television, by A. H. Brolley, Television Labs. Feb. 4. Att. 68.

Design of the Portable Motor Generator Set Which Was Used by the Byrd Antarctic Expedition, by Mr. Heintz, Heintz and Kaufman. Joint meeting with A.S.M.E. Branch. Feb. 10. Att. 42.

### Stevens Institute of Technology

Personnel Work in the New York Edison Co., by Prof. F. C. Stockwell, counselor. Feb. 5. Att. 38.

The Setting of Clocks by Radio, by Prof. H. C. Roters. Feb. 16. Att. 26.

### Syracuse University

The Piezo Electric Effect and Its Utilization, by J. L. Schmieder, Jr., student; History of the Telephone, by Wm. Bangs, student. Feb. 12. Att. 21.

Control Frequency Broadcast, by L. G. Curry, student; Electrolysis of Cast Iron Pipe, by H. Coswell, student. Feb. 19. Att. 21.

The Earth as a Current Conductor, by F. DeBoalt, student. Feb. 26. Att. 21.

### A. & M. College of Texas

Some Developments by G.E. in 1931, by W. Clayton, Gen. Elec. Co. Illustrations. Various G.E. Products, by Mr. Alen, Genl. Elec. Co. Feb. 11. Att. 94.

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Feb. 25. Att. 800.

### Texas Technological College

Life of Thomas A. Edison, by W. Nott, student. Slides. Feb. 11. Att. 14.

### University of Texas

Harmonic Analysis of Distorted Wave Form, by Dr. S. L. Brown. Feb. 11. Att. 12.

### University of Utah

The History of Amateur Radio, by L. K. Irvine, student. Discussion. Jan. 28. Att. 37.

Debate: Resolved: That the Engineer Has Caused the Depression. Affirmative—D. Ashby, R. C. Hansen, students. Negative—S. Ramo, R. Kirkman, students. Negative side won. Feb. 25. Att. 36.

### University of Vermont

The Effect of Electrode Shape on High Voltage Stresses in Insulators, by Mr. Whitman. Illus. Feb. 15. Att. 19.

### Virginia Polytechnic Institute

Light Relays and Light Source Units, by R. W. McCorkle, student; Power Auxiliaries, by H. E. Naylor, student; Active and Inactive Duties of the Advanced R.O.T.C. Student, by M. H. Mills, student; Electric Heating and Wood Block Floor Construction, by C. K. Luck, student. Feb. 11. Att. 47.

Method of Weighing Small Particles, by W. C. McCall, student; Oil Filled Cables, by W. L. Outten, student; The Prerequisites of an Electrical Engineer, by G. R. Snyder, student; High Speed Submarine Cables, by A. I. Osborne, student; New Power Transformers, by T. E. Gilhooley, student; Electrical Operation of Dredges, by A. L. Pond, student. Feb. 18. Att. 54.

Use of Natural Has for Generating Electrical Energy, by J. H. Pharis, student; Three Power Locomotives, by J. E. Hamm, student; Electro-Plating, by A. M. Potts, student; The Economic Phase of Electrified Railroads, by W. C. Cottrell, student. Feb. 25. Att. 54.

The Oscillograph, by H. A. Frazier, student; The Life of Samuel Morse, by R. E. Philbeck, student; Load Ratio Control for Transformers, by C. L. Tune, student; Development of Transcontinental Radio Telephones, by D. H. Smith, student; Dial System Automatic Telephones, by E. L. Rowell, student. March 3. Att. 50.

### University of Virginia

The Qualifications of an Electrical Engineer, by R. B. Jones, student; Traffic Operated Traffic Signal, by B. G. Switzer, student; Believe It or Not—Pertaining to Electrical Engineering, by T. J. LoCascio, student. Feb. 12. Att. 26.

### Washington State College

Election of officers as follows: Philip Nalder, pres.; T. Torkelson, vice-pres.; Gus H. Bliesner, secy.; H. Brittenham, treas. Jan. 29. Att. 22.

Power Plant Achievements for 1931, by R. Uhlig, student; Electrical Instruments, by Prof. O. E. Osburn, counselor. Feb. 12. Att. 26.

### University of Washington

Televox, by W. Blashfield, student. Feb. 4. Att. 11.

Electrical Reflections in Induction Motors, by D. J. Moore, student. Feb. 11. Att. 15.

The Public Utilities Place in the Electrical Industry, by H. A. Gardner, Puget Sound Pwr. & Lt. Co. Feb. 18. Att. 17.

Film—"Conowingo." Feb. 25. Att. 72.

Diablo-Seattle Transmission Line, by C. M. Lubcke, Engg. Dept., City of Seattle. March 5. Att. 27.

### West Virginia University

History of Rate Making, by H. Locker; Diesel Engines as Peak Load Units, by L. Palmer; An Interview of Dr. H. C. Rentschler, by P. B. Spangler; Engineering Features of Three Power Locomotives, by E. D. Harris; Remote Reading of Watt Hour Meters, by L. P. Kirwin; Vacuum Tube History, by K. H. DeMoss; The Dynamic Radio Microphone, by P. M. Vannoy; all students. Feb. 9. Att. 31.

Power for an Arctic Elevator, by J. L. Simpson; Automatic Combustion Control, by R. H. Colborn; Measuring High Radio Frequencies, by N. I. Hall; Shocks Due to Electricity, by L. H. Winger; Communication in the Waldorf Astoria, by M. Stewart; Photoelectric Recorder, by W. C. McMillian; Foreign Jobs, by W. C. Sandy; all students. Feb. 16. Att. 31.

Development of the Chinese Electrical Industry, by M. Sprigg; Remote Reading of Watt Hour Meters; by D. C. Kennedy; Electric Heating in Wood Block Floor Construction, by J. E. Wallace; Corona Versus Conductor Surface, by F. O. Brown; Transoceanic Radio Telephone Service, by C. J. McCormick; all students. Feb. 23. Att. 29.

Gas Electric Railway Car, by R. H. Colburn; All Wave Radio Receiver, by N. I. Hall; Electrical Units and Their Application, by C. J. DeLancy; Electricity on the Airship Akron, by L. H. Winger; Reducing Noises From Power Transformers, by W. C. Sandy; all students. March 1. Att. 29.

### University of Wisconsin

The Private Life of Michael Faraday, by M. L. Dack, student; Michael Faraday's Experiment, by P. E. Patterson, student; Electrical Researches of Faraday, by J. K. Affanasiey, student. Dec. 10. Att. 47.

Dancing Conductors, by W. A. Kuehlthau, student. Moving pictures. Jan. 19. Att. 64.

Electrical Engineering Only? by Charles Moore, Bell Tel. Labs., Inc. Feb. 11. Att. 76.

### University of Wyoming

Electron Theory, by Dr. P. F. Hammond, head, physics dept. Joint meeting with A.S.M.E. Branch. Feb. 23. Att. 17.

## Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Berry, Wayne J., c/o Genl. Elec. Co., Schenectady, N. Y.
Bugg, Vernon, 736 Transportation Bldg., Washington, D. C.
Combs, Clinton R., 13564 Northlawn Ave., Detroit, Mich.
Fay, John L., Genl. Del., Philadelphia, Pa.
King, Milton E., 1521 Laketon Rd., Wilkinsburg, Pa.
Master, J. J., 36–7 Canning St., Calcutta, India.
Miyamoto, Tatsuo C., 1330—4th St., Sacramento, Calif.
Palit, Hari-Charan, 151 Ganesh Mohal, Benares City, India.
Rogge, C. A., Consumers Pwr. Bldg., Jackson, Mich.
Thomas, Earl Mead, Intl. Genl. Elec. Co., Schenectady, N. Y.
Titland, Trygve T., 1019 Stanton Ave., Elizabeth, N. J.
Van Der Dussen, John, 114 Gotham Ave., Gerrittsen Beach. B'klyn, N. Y.

# Employment Notes

## Of the Engineering Societies Employment Service

## Men Available

### Construction

DISTRIBUTION ENGR., 29, married, tech. grad. 8 yr. experience in utility field as supt., mgr., engr. foreman, and lineman. One year constructing municipal power and ice plant. Eighteen months elec. installation in large industrial establishment. Available immediately. Location, immaterial. D-442.

ASSOC. E.E., 25, 8 yr. practical experience in elec. construction work on new bldgs., power plants, and alterations. Familiar with all branches of elec. contracting including field engg. and inspections. Has had complete charge of elec. design and construction outside of New York City. Excellent references. D-502.

ELEC. CONSTRUCTION ENGR., E.E. Grad., 1928, 28, married. 3 1/2 yr. experience with large elec. contractor in estimating, design, control work and field supervision. Also 3 yr. experience in accounting, cost and stenographic work. Excellent references. Available immediately. D-46.

E.E., 33, with 10 yr. practical experience in elec. construction work on new bldgs. Familiar with all branches of elec. contracting including estimating, field engg. and purchasing. Have been in complete charge of elec. work in various large building projects in New York City. A-850.

### Design and Development

E.E. GRAD., 35, single, mfg., maintenance, operation, designing experience. Inventions. Foreign languages. Desires responsible position with mfg. industry. (Development or production. Transformers; elec. locomotives; control, etc.) Location, immaterial; eastern preferred. D-452.

FORMER CORNELL INSTRUCTOR IN MACHINE DESIGN for 4 years, Allis-Chalmers designer and checker 5 years, M.E. and E.E. deg., shop apprenticeship and miscellaneous experience, 32, single. Desires teaching or engg. opportunity. Salary open. D-122.

DESIGN ENGR., col. grad., 38, married, citizen; 6 yr. elec. plant construction, wide experience all features design of pwr. and substations and industrial light and pwr., 3 yr. field experience as tester and supervisor. Desires position with utility, engg., or construction firm. Available immediately location, immaterial. D-482.

ELEC.-MECH. ENGR. with metallurgical knowledge. Col. grad. with post-graduate study, 30, married. Westinghouse design training. 6 yr. experience design elec. circuits and mechanical details of control apparatus, specialized in elevator equipment. Interested in alloy welding research. Location, immaterial. Available on short notice. C-9638.

E.E., GRAD., M.I.T. 1925, 30, married, 6 yr. utility design and engg. Capable complete elec. design steam, hydro station, high-, low-voltage

## ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
San Francisco

205 West Wacker Drive
Chicago

31 West 39th St.
New York

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

**Men Available.**—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

**Opportunities.**—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

**Voluntary Contributions.**—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

**Answers to Announcements.**—Address the key number indicated in each case and mail to the New york office, with an extra two-cent stamp enclosed for forwarding.

substations. Short circuit, relay studies large networks. Knows industrial control design. Available at once. Location not important. C-6366-322-C-5-San Francisco.

DESIGN ENGINEER, E.E. GRAD., 10 yr. power plant, d-c. rectifier substations, industrial and illumination experience. Expert draftsman, mathematician, knowledge of vacuum tubes, photocells, and their application in industry. Contributed many articles in engg. journals on original developments. East preferred, available immediately. B-7332.

E.E. GRAD., 45, married, G. E. Test and design experience; over 15 years' experience with larger companies in design and manufacture of transformers for special requirements, as well as standard lines. Desires position with utility or mfr. where experience will be valuable. Available on short notice. C-8806.

E.E. GRAD., 1930, 23, single, cooperative experience. 3 yr. with utility in central station design and construction. 1 yr. designing automatic pumping installations, floodlighting and general lighting, carrying full responsibility for all designs. Available immediately. Location, East preferred. D-561.

E. E. GRAD., 27, married. 5 yr. experience elec. and mech. design motors, fractional hp. to 500 hp. a-c. and d-c. 1 yr. experience substation and transmission line design. Grad. radio school. Thoroughly familiar with mfg. problems. Capable of assuming responsibilities of design. Nationally known references. Location, immaterial. Available immediately. D-565.

E.E. GRAD., 29, single, 2 yr. additional study in accounting. 5 yr. experience elec. and mech. design and development of fans and small motors with leading mfr. Desires position with mfg., utility or engg. concern or teaching elec., mech. drawing. Location, East. D-580.

ELEC. AND MECH. DESIGN ENGR., 48, E.E. grad., LL.B. and attorney at law. Power houses, substations and gen. steel mill engg. with special training in legal work connected with industrial concerns. Available at once. Preferred location, Ohio or Pittsburgh district. D-589.

E.E., 38, single. 13 yr. experience in design of mchy., apparatus, substations, hydro and steam pwr. plants with well known concerns, $6\frac{1}{2}$ yr. in last position. Desires connection with concern where ability and adaptability will lead to advancement. C-347.

### Executives

CONSTRUCTION: ASSOC. E. E., 32, 16 yr. practical experience, elec. construction on new bldg. and repair work, familiar with all branches of elec. contract work including estimating, engg., purchasing, and inspection. 10 yr. in charge of elec. contract dept. for an elec. contractor. Location, immaterial. Available immediately. Salary open. D-478.

E.E. GRAD., married, 23 yr. experience in engg. and exec. capacities in industrial plants covering design, layout, contracting and purchasing of mfg. equip. and power plants including mech., elec., refrigerating, air-conditioning, and new processes for soap, drug, candy food products, and textile plants. D-488.

E.E., B.S. M.S. deg. 45, experienced in utility and industrial applications. Permanent position desired. D-498.

E.E. GRAD., 35, married. 5 yr. experience in system operating planning with utility, also sales, construction and some elec. maintenance experience. Past 2 yr. as design engr. with large elec. mfg. company. Can become valuable in any position. Exec. desired. Available now. Location, immaterial. B-7827.

GRAD. E.E., professional engr. license N. Y. State, 10 yr. experience elec. pwr. plants, substations, distribution, lighting, industrial installations, and specifications, wishes connection with firm which can use man possessing chief characteristics as: Speed, thoroughness, willingness to work hard, accuracy, energy. Part or full time. Excellent references. D-454.

GRAD. E.E., 32, single. 9 yr. design and construction of pwr. transmission lines, substations and distribution networks as engg. inspector, purchasing, expeditor, preparing estimates and writing specifications. Excellent references. Desires connection with holding or operating company, contractor or mfr. Available immediately. Location, immaterial. C-3564.

E.E. GRAD., 4 yr. experience, drafting, design, construction, and engg. of modern hydro and steam pwr. plants, substations and ry. electrification. $5\frac{1}{2}$ yr. with leading mfg. concern in engg. of automatic and manual switchgear equipment. Foreign languages. Desires position, utility, engg., mfg. or ry. concern. Location, immaterial. B-7938.

E.E. GRAD., 26, married. 5 yr. with engg. dept. of holding company until merger, full experience in design, supervision and construction of substations and transmission lines. One year G. E. Test. Licensed electrician. Knowledge of radio testing and servicing equip. Available immediately. D-568.

E.E., 36, family. 15 yr. with engg. organizations: reports, designs, layouts, construction, performance tests, contracts and purchase, large industrial plants, utility pwr. plants, substations and network distribution systems; executive experience. Registered in Pa. Unemployed. Prefers consulting, maintenance, design, sales work in East, but will consider any location. C-2570.

E.E., Univ. of Va., 1924, single, desires place requiring hard-working tech. engr. of genl. experience in engg. dept. of utilities and cable mfr. on transmission circuits, elec. measurement and equip., inductive coordination, and insulation and cables in particular. Will accept temporary position in U.S. to prove ability. C-2282.

E.E. GRAD., 37, married. 4 yr. design on motors, control, steam turbines and engines. 8 yr. production, development, experimental work on centrifugal pumps and air compressors, elec. control equip. B-6926.

E.E. AND ESTIMATOR, 26 yr. experience, estimating, supervising and engg. for contractors, engg. for architects, etc., would like position with elec. contractor. Best of references. East or South preferred. C-8460.

E.E. GRAD., 14 yr. experience utilities in valuation work, rate investigations, engg. pwr. plants, substations, transmission lines, including estimates, specifications, design. Experience covers short-circuit studies, stability analysis, investigations of systems for load conditions. Desires position holding or operating company, or engg. firm. Available immediately. C-9570.

E.E. GRAD., experienced in elec. pwr. field desires position with pwr. company or mfg. firm. Able to supervise drafting, construction, and maintenance. B-1923.

CHIEF E.E., 36, E.E. grad. Extensive experience charge of design, construction, operation, maintenance plant, substations, transmission, trolley, telephone lines; maintenance elec. rolling stock, steam train lighting, elec. drive, lighting equip. factories, shops, offices, etc. Record of rapid advancement. Good organized. Successful handling Latin-American labor. Speaks Spanish. School grounding in French. C-9557.

E.E., experienced in load forecasting for economical planning for future growth. Established methods and records for systematic handling of estimates on property including 300 communities. Familiar with unit costs, estimates, and budgeting. Also experienced in elec. planning, design, and construction of transmission, substations and distribution. B-2876.

TECH. GRAD., married, 38, with $11\frac{1}{2}$ yr. experience as distribution, field and office engr.; $4\frac{1}{2}$ yr. tests, shop and construction work; desires position in engg. or operating dept. of utility. Location, immaterial. Available immediately. B-9248.

### Instruction

GRAD. E.E., 1929; M.S. deg. 1931, Ohio State Univ. Ph.D. requirements partially completed. Experience in the fields of telephony, acoustics, and ry. signalling. Desires engg. or teaching position. Location, immaterial. D-475.

GRAD.; E.E., M.I.T., 35, married. 6 yr. industrial and teaching experience in E.E. Several years private research and development work on own initiative. Good ability, integrity, and personality. Desires position for life work. Location preferred, Middle West or South. C-2836.

ENGINEER-INSTRUCTOR; B.S., M.A.; 36, married. Desires college teaching connection. Teaching and lecturing experience, 10 yr. research and radio experience. Can teach E.E., radio, and physics. Available in fall or summer. C-1087.

PROF. OF E.E., B.S., and E.E. deg. 41, 6 yr. successful experience teaching practically all branches of E.E., state school. Considerable experience power, telephone work. 1 yr. switchboard engg. dept. Westinghouse. Available school year 1932–33. C-5021.

E.E. GRAD., 33, married. $3\frac{1}{2}$ yr. service engr. on pwr. and industrial apparatus and control. 2 yr. instructor in E.E. at state univ. 2 yr. transformer design and genl. engg. $\frac{1}{2}$ yr. pwr. and substation construction. Desire engg. opportunity or teaching. C-1073.

E.E. PROF., B.S., and E.E., 33, married. $2\frac{1}{2}$ yr. G.E. Co., 5 yr. with utility, 4 yr. teaching, 1 yr. as acting head of dept. Desires change. Location, South or Middle West preferred. C-7152.

ASST. PROF. E.E., leading tech. col. of East, desires position, industrial concern where knowledge and experience gained in 14 yr. teaching fundamental courses in E.E. can be utilized in development, research, construction. M.I.T. graduate, married, 35, perfect health. Interested especially, elec. measurements, measuring instruments. Experienced draftsman, checker. D-581.

### Maintenance and Operation

E.E., GRAD., married, 28; wide experience in industrial plant elec. construction and maintenance; ry. electrification; pwr. plant design, estimating, and supervistory construction experience with elec. contractor; cost analysis. Desires position with future. C-4428.

E.E. GRAD., 1928, 6 yr. hydro and steam plant elec. operation and maintenance, 5 yr. office and cost accounting. Would desire position with utility or mfg. concern in any part of U. S. or foreign. Salary secondary to opportunity. C-7796.

### Junior Engineers

E.E., 28, married. Experienced in capacity of load dispatcher of pwr. Co., having interconnections with other companies. 6 yr. college work, including business training. D-468.

GRAD. E.E. 1931, Rensselaer Poly. Inst., single, 23. Desires position with any reliable engg. firm with opportunity for advancement. Salary immaterial. Wide engg. training. Best of references. Location, Eastern preferred or will consider any location. Available immediately. D-470.

E.E. GRAD., 1929, 26, single. 3 yr. experience in oil burner control equip. $1\frac{1}{2}$ yr. head of experimental test dept. of large mfr. of automatic heat control equip. Location preferred, Middle West. Available at once. D-486.

E.E. GRAD., 1931, single, 22. Experience in drafting and design of switches and pwr. distribution panels. Desires position in utility service and transmission of pwr. Also interested in research in the various branches of physics. Location, immaterial. Available immediately. D-471.

E.E. GRAD., 1929, M.S. 1931, leading univ., 18 months G.E. Test, 23, single. Desires to teach in tech. univ. Prefers Mid-West. C-9320.

E.E. GRAD., 22, 10 months' experience on construction. Desires employment with utility, engg., or mfg. concern. References furnished. Available with short notice. C-9885.

E.E. GRAD., 24. 3 yr. experience in industrial installation and control. Dull experienced with a-c. or d-c. elec. automatic drives and control. Desires position with utility or mfg. concern. Location, immaterial. Available on month's notice. C-8763.

GRAD. E.E., Univ. of North Carolina, 1931, 22, single. Extra study liberal arts and commerce schools. Desires position any engg. field, preferably telephone work. Four summers experience, Ill. Bell Telephone Co., installation and maintenance. Salary immaterial at start. Any location, foreign or U.S. Available immediately. D-527.

E.E. GRAD., 1931, 25, single, cooperative college. Limited experience with battery mfg. concern. Desires position with a future. Salary and location secondary. Available at once. D-534.

JUNIOR PHYSICIST experienced in X-rays, spectroscopy and elec. measurements available for research lab. or instructorship. M.S., Purdue, 1932. Speaking and reading knowledge of German and Spanish. At present asst. in physics. Available July. C-7387.

ELECTROCHEMICAL ENGR., 26, single. B.S. in E.E. and Ch.E. 3 yr. experience as field service engr., recording and controlling instruments. Also some sales. Refrigeration, time study and industrial engg. training. D-507.

GRAD. E. E., 1931, 24, specialized in hydraulics. Has had experience in large hydro plant. Desires position in the elec. industry. Location, immaterial. Available immediately. D-543.

E.E. GRAD., 1929; 27. 2 yr. on test floor of Westinghouse; also knowledge of radio and sound reproducing equip. Will accept small salary. Location, immaterial. Available now. D-542.

JR. ENGR., 22, single; 1932 grad. Desires position in elec. industry, preferable radio or one of its affiliated branches. Licensed radio operator. Salary secondary to opportunity. Available on short notice. Location, U.S. or foreign. D-544-323-C-1-San Francisco

GRAD. E.E., 1929, single, 23. 15 months student engr. on G.E. Test. Some test, drafting, and switchboard construction experience before graduation. Interested in position with concern doing consulting or construction work or with utility or mfr. Available at once. Location, anywhere in U.S. but New England preferred. C-8028.

E.E., Cornell Univ., 1931, E.E. deg., single, 22. Holds limited broadcast operator's license. Desires position in any elec. engg. field. Available immediately. D-519.

E.E. GRAD., 1931 M.I.T. (communications), 23, single. Radio experimenter for 10 years. Experience in radio repairing. Desires employment preferably in research or design work with radio, elec. instrument, television, or sound concern. East preferred, but elsewhere considered. Salary secondary. Available on short notice. D-553.

E.E., GRAD. 1929, 25, single, Phi Kappa Phi. 11 months, G.E. Test followed by 2 yr. on G.E. switchgear engg. covering application, development, testing, specifications, field servicing. Good scholastic and efficiency record. Desires connection with utility or engg. corp. Willing to start at bottom. U.S. or foreign. D-560.

E.E. GRAD., 1931, Univ. of Wash., 22, single. Will accept any position, any location. Research preferred. Good scholastic record. D-569.

GRAD. E.E., Stanford Univ., single, 24, desires connection with utility, sound picture industry, or radio mfg. firm. Experienced in genl. office work. Good draftsman. Location, immaterial. D-571.

E.E. GRAD., 1931, midwestern col., single, 24, American. Excellent scholastic record. Desires teaching opportunity. Will teach E.E., mathematics or mechanics. Location, immaterial. D-570.

E.E. GRAD., 1930, 23, single, 15 months on G. E. Test giving test experience with railway equipment, rectifiers, industrial apparatus, industrial control, and refrigeration developmental. Desires position with utility or mfg. concern. Available at once. D-409.

GRAD. E.E., 1931, midwestern col., 4, single. 3 yr. experience in genl. maintenance, construction and motor testing. Location, immaterial. Available at once. D-572.

E.E. GRAD., 1931, Lehigh Univ., 22, single. Summer experience with utility or industrial concern. Eastern states preferred, but other locations considered. Available at once. D-301.

E.E. GRAD., 1931 from Worcester Poly. Inst., member Sigma Xi, 22, single, desires connection with utility concern, industry, or with teaching, also interested in drafting. Location, immaterial. Available at once. D-228.

E.E. GRAD., Univ. of Pittsburgh, '31, cooperative col., single, 23. Westinghouse test and Bell Telephone experience. Desires many kind of engg. or engg. sales work in Eastern part of U.S. D-594.

E.E. GRAD., 1930, E.E., 1931, from Univ. of South Carolina, 23, single. 6 months' experience with South Carolina Pwr. Rate Investigating Committee. Able and willing to do practically any type of engg. work. Available immediately. Location, immaterial. Can give best of recommendations. D-595.

### Research

RESEARCH AND PATENT ENGR. in radio and television field as well as in genl. elec. engg. seeks permanent connection with a stable organization. D-516.

E.E. GRAD., M.I.T., cooperative, 28, single, 4 yr. experience in planning section of large utility making transmission studies, field tests, and foreign wire relations. Wants connection with ry., utility, or mfr. anywhere in U.S. Available on short notice. D-536.

### Sales

MANUFACTURERS AGT. OR SALES ENGR. Southern Calif., 48, 10 yr. engg. work, 12 yr. sales including 5 yr. South Am., good ability, integrity, personality, and knowledge of Spanish, used to pioneering and hard work, salary or commission, part or all time. B-9095.

# Membership

## Recommended for Transfer

The board of examiners, at its meeting held March 2, 1932, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the assistant national secretary.

### To Grade of Member

Armstrong, Emerson A., mgr., pwr. sales, Pub. Serv. Co. of Northern Illinois, Chicago
Bunch, Charles H., secy.-treas., Acme Elec. & Mfg. Co., Cleveland, O.
Chatham, Clyde L., engr., Pub. Serv. Elec. & Gas Co., Newark, N.J.
Ebert Edward, Jr., asst. engr., Bklyn. Edison Co., Brooklyn, N.Y.
Grandy, Lewis S., assoc. prof. of elec. engg., Texas Tech. Col., Lubbock, Texas
Hauser, Oscar E., engr., meter dept., Detroit Edison Co., Mich.
Manby, A.W., supt., Chatts Falls Dev., Hydro. Pwr. Comm. of Ontario, Fitzroy Harbour, Ont.
Morrison, John W., ch. engr., Rochester Telephone Corp., N.Y.
Parmenter, Robert J., designing engr., Pub. Serv. Co. of Northern Illinois, Chicago
Pierce, Donald A., engr., inductive coordination Pub. Serv. Co. of Northern Illinois, Chicago
Schneider, Matthew S., operating engr., Union Gas & Elec. Co., Cincinnati, O.
Tarboux, Joseph G., prof. in charge of elec. engg. dept., Univ. of Tennessee, Knoxville

## Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the assistant national secretary before April 30, 1932.

Andersen, A. W., University of Mich., Ann Arbor.
Armstrong, R. W., Elec. Installation Co., Boston, Mass.
Ballard, H. N., Puget Sound Pwr. & Lt. Co., Seattle, Wash.
Barrett, C. B., Western Elec. Co., Kearny, N. J.
Bateman, I. L., City of Los Angeles, Calif.
Beall, M. F., Univ. of Mich., Ann Arbor.
Bell, G. M., Canadian Westinghouse Co., Hamilton, Ont.
Beyer, N. S., Price Waterhouse & Co., San Francisco, Calif.
Bissell, C. H. (Member), Crouse-Hinds Co., Syracuse, N. Y.
Blackmon, H. N. (Member), Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Bugnion, F. E., 14 Clinton St., Cambridge, Mass.
Callicott, J. B., Pub. Service. Co. of No. Ill., Northbrook.
Caplow, A. I., 10010 Parkgate Ave., Cleveland, Ohio
Carlson, C. N., 264 Glenwood Ave., E. Orange, N. J.
Church, P. T., Kim Bean Co., Kim, Colo.
Clark, H. D., Conn. Lt. & Pwr. Co., New Britain.
Coe, J. C., War Dept., Wright Field, Dayton, Ohio
Cook, F. R., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Craig, R. M., Hartford Steam Boiler Inspec. & Ins. Co., Pittsburgh, Pa.
Cramer, H. B., Brooklyn (N. Y.) Edison Co.
Dame, F. E., New York (N. Y.) Edison Co.
Dean, C. F., Chevrolet Motor Ohio Co., Toledo
Dee, T. C. (Member), 808 Third St., Jackson, Mich.
Devitt, W. E., Gen. Elec. Co., Schenectady, N. Y.
Dilley, B., Union Gas & Elec. Co., Columbia Park, Ohio
Dozer, H. E., Nat. Elec. Prod. Corp., Cleveland, Ohio
DuBois, W. R., DuBois Radio Serv., Mogadore, Ohio
Eggleston, L. A., Cornell Univ., Ithaca, N. Y.
Engster, F. W., Gen. Elec. Co., Schenectady, N. Y.
Ewald, G. A., Pub. Serv. Elec. & Gas Co., Newark, N. J.
Ferrin, A. J., 502 North Jackson, Pratt, Kans.
Fey, H. J., Univ. of Wash., Seattle.
Forbes, A. G., Fred Hall's Ranch, Eden, Tex.
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Woodford, A. G., Allen Bradley Co., Milwaukee, Wis.
Wright, H. D., Pac. Gas & Elec. Co., San Francisco, Calif.
Zacherl, F. A., 128 Main St., Clarion, Pa.
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Patel, B. J., B. B. & C. I. Rly., Bombay, India
Rao, C. V., Anglo-Persian Oil Co. Ltd., Abadan, Persia
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# Engineering Literature

## New Books

### In the Societies Library

Among the new books received at the Engineering Societies Library, New York, during February are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no reponsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

RAILROAD CONSTRUCTION, Theory and Practise. By W. L. Webb. 9th ed. N. Y., J. Wiley & Sons, 1932. 8x5 in., leath., $6.00. Pt. 1, 699 p.; Pt. 2, Tables, 226 p.—Deals with all phases of construction from the preliminary survey to the completion of the road and provision of the rolling stock. The present edition is largely new, the author having incorporated improved methods devised in recent years. Necessary mathematical tables are included.

MODERN DIESEL, a review of high speed compression ignition engines. London, Iliffe & Sons., Ltd., 1932. 142 p., 8x5 in., cloth, 2s 6d.—An elementary handbook on the origin, principles of construction, and its advantages. The principal types for automobiles, aircraft, and marine service are described briefly.

HUMAN ENGINEERING. By H. Myers. N. Y. & Lond., Harper Bros., 1932. 318 p., 8x6 in., cloth, $3.—The author, a physician, and management engineer, discusses the management, hygiene, and other topics pertaining to personnel problems.

HEAT ENGINES. By S. H. Moorfield and H. H. Winstanley. London, Edward Arnold & Co., 1931. 287 p., 8x5 in., cloth, $2.25.—An elementary textbook. Presenting the underlying principles clearly and concisely.

GRAPHIC STATICS. By S. Fairman and C. S. Cutshall. N. Y. & Lond., McGraw-Hill Book Co., 1932.—145 p. 9x6 in., cloth, $1.75.—The distinguishing feature is the grouping of three important topics in one volume. The book represents the course offered to engineering students at Purdue University.

ELEKTRISCHE HOCHLEISTUNGSÜBERTRAGUNG AUF WEITE ENTFERNUNG. By R. Rüdenberg. Berlin, J. Springer, 1932. 370 p., 9x6 in., cloth, 31.50 rm.—A series of lectures upon the problems of long distance power transmission, given under the auspices of the Electrical Engineering Society of Berlin and the Berlin Engineering University, by experts from the large electrical companies; discusses in a practical way the theory of a-c. transmission and of long lines, generators, and transformers, compensation, regulation, interconnection, breakdowns, and the economics of a-c. and d-c. transmission.

ECONOMICS OF PUBLIC UTILITIES. By L. R. Nash, 2nd ed. N. Y. & Lond., McGraw-Hill Book Co., 1931. 508 p., 9x6 in., cloth, $4.—To provide in one volume a comprehensive treatment of the underlying economic facts governing public utility considered as a business. Carefully revised and a chapter upon holding companies added. New material upon political activities and agitations against public utilities, legislation on interstate transportation, natural gas movements, and electric power transmission, also has been added.

COMMUNICATION ENGINEERING. By W. L. Everitt. N. Y. & Lond., McGraw-Hill Book Co., 1932. 567 p., 9x6 in., cloth, $5.—A text-book covering the fundamentals of communication by wire and wireless networks which aims to provide a balanced course stressing broad principles rather than specific applications. Author believes the work will be valuable also to the power field, as communication systems and power systems differ primarily in the complexity of their networks.

BEITRÄGE ZUR GESCHICHTE DER TECHNIK UND INDUSTRIE, V. 21. Ed. by C. Matschoss. Berlin, VDI-Verlag, 1931–2. 188 p., 12x8 in., cloth, 10.80 rm.—The 21st volume of annual of engineering history; contains a number of valuable papers, a review of articles published elsewhere, reports on existing ancient engineering works and on museums of industry, and a bibliography of historical publications of the year. Essays on the discovery of magnetic induction development of electric heating during the nineteenth century, early knowledge of the magnetic compass, the development of reinforced concrete, and the history of hydraulic works in China.

### Engineering Societies Library

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MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

MODERN MILLING OF SUGAR CANE. By F. Maxwell. Lond., Norman Rodger, 1931. 423 p., 10x8 in., cloth, 50s net.—A welcome addition to literature of sugar manufacture. Dr. Maxwell confines himself to the latter stage and presents an account of milling practise in the leading sugar-producing countries. The machinery used is freely described, including prime movers and such topics as electric drives, the operation of milling trains, and milling control.

COLOUR SCIENCE, Part 1. By W. Ostwald. Authorized translation with introduction and notes by J. S. Taylor. Lond., Winsor & Newton, Ltd., 1931. 141 p., 9x6 in., cloth, 15s.—This translation of the first part of "Farbkunde," treating of the theory and standardization of color, has been revised and supplemented by the author.

KINETICS OF HOMOGENEOUS GAS REACTIONS. (American Chemical Society Monograph Series.) By L. S. Kassel. N. Y., Chemical Catalog Co., 1932. 330 p., 9x6 in., cloth, $6.50.—This reviews critically, from a single point of view, information available upon the reaction kinetics of homogeneous gases. The subject is treated theoretically and experimentally in separate sections of the book. The theoretical treatment discusses the principles governing the rates of chemical reaction; the experimental part, all of the available data. Numerous references occur in footnotes.

HILFSBUCH FUR DEN TECHNISCHEN AUSSENHANDEL. By E. K. Lubowsky. Berlin, Hermann Wendt, 1931. 808 p., 10x7 in., cloth, 42 rm.—The purpose of this handbook is to enable the foreign representative of an exporter to anticipate fully the information which the home office must have before it can intelligently submit tenders for machinery or electrical equipment. 450 outlines are given covering various machines. The text is in English, German, French, and Spanish, fully indexed in each.

PLANNING PROBLEMS OF TOWN, CITY, AND REGION. Papers and discussions at the 23rd Natl. Conference on City Planning, Rochester, N. Y., June 22–24, 1931, publ. by Wm. F. Fell Co., Phila., 1931. 228 p., 9x6 in., cloth, $3.00.—Topics discussed are: Is city planning effective control of city growth? Mass transportation on city streets; master plans and official maps; zoning and administration; edges of zones; county planning; relation of special assessments; planning programs for small cities; prevention of blight adjacent to expressways.

RELAY HANDBOOK AND SUPPLEMENTS, 2 ed., 1931. Natl. Elec. Lt. Assn., N. Y. 1381 p., tables, 7x5 in., lea., $4.00 to members; $6.00 to nonmembers.—This new edition consists of a reprint of the handbook with a 367-page supplement and combined index, obtainable as a separate volume.

DIESEL REFERENCE GUIDE. By J. Rosenbloom originally announced in ELECTRICAL ENGINEERING, Jan. 1931, p. 76, now is available at $4 per copy instead of $10 as announced previously. Publishers agents: Rider Press, N. Y.

# Industrial Notes

**New Combination in Copper Field.**—Effective March 21, the newly formed Phelps Dodge Copper Products Corporation took over and will operate the following fabricating units as divisions: the American Copper Products Division, with mills at Bayway, N. J., manufacturers of copper rods, bus bars, trolley wire, weather proof wire, etc.; The British American Tube Division, Bayway, N. J., condenser tubes, copper tubes, and pipe, etc.; Inca Manufacturing Division, Fort Wayne, Ind., enameled copper wire, coils, and magnet wires; P-M-G Metal Division, Bayway, N. J., copper and copper alloy products.

The Habirshaw Cable and Wire Corporation will maintain its separate corporate existence and will be operated as a subsidiary of Phelps Dodge Copper Products Corporation. With mills at Yonkers, N. Y., and Bridgeport, Conn., it manufactures rubber and lead covered copper wire, paper, and varnished cambric insulated power cables, and other electrical conductors.

The name of the present fabricating subsidiary, National Electric Products Corporation, will hereafter be the corporate title of the National Metal Molding Division of the company only, with headquarters at Pittsburgh. Its plant is at Ambridge, Pa., and the principal products are rigid and flexible steel conduits, metal molding, outlet boxes, etc. Wylie Brown is president of both the Phelps Dodge Copper Products Corporation and the Habirshaw Cable and Wire Corporation. Both companies have moved their offices and are now located at 40 Wall Street, New York. Through acquisition of the Calumet and Arizona Mining Company, and prior acquisition of the Nichols Copper Company and the National Electric Products Corporation, Phelps Dodge Corporation is one of the three large units in the copper industry in the United States.

**New Disconnecting Link Boxes.**—The G & W Electric Specialty Company, 7780 Dante Avenue, Chicago, has developed a new device for simple and economical sectionalization of high tension cables. It is an oil-filled, disconnecting link box, comprising an assembly of standardized parts, and is produced at low cost to meet individual requirements.

**New Electrode for Welding Aluminum.**—The Lincoln Electric Company, Cleveland, Ohio, announces a new electrode for welding aluminum which will be known as "Aluminweld." The new electrode is a 5 per cent silicon aluminum alloy; can be used for welding sheet or cast aluminum, and is designed for either metallic or carbon arc welding.

**A New Vacuum Contact Relay.**—The Ward Leonard Electric Company, Mount Vernon, New York, has added a vacuum contact relay to its line of midget relays. The vacuum contact element, which is actuated by the relay armature, is rated at 8 amperes intermittently and 6 amperes continuously at 220 volts. Relays equipped with this type of contact are especially applicable to operation in hazardous places and have a high rating, making them a heavy duty midget relay. These relays may be obtained for normally open or normally closed operation. Coils may be wound for 6 to 110 volts alternating or direct current.

**A New Mercury Switch.**—The CeCo Manufacturing Company, Inc., Providence, R. I., has formed an industrial division to develop electrical and electronic devices for industrial purposes. One of the products of this division is the "Mertact," a mercury electric switch. Mertacts are made in sizes from 1 to 100 ampere capacities. Sizable currents can be broken by a very small mechanical force, often eliminating the necessity of using intermediate relays. The new switch has a wide field of application in electric appliances, heating devices, automatic temperature control, and in equipment that requires frequent make and break of current. C. O. Cressy will be the engineer in the industrial division assigned to the application of this division's products.

**Outdoor Switch Houses.**—The Delta-Star Electric Company, Chicago, has developed a line of metal clad, outdoor switch houses for medium capacity distribution circuits. They are equipped with T.P.S.T. solenoid operated, trip-free oil breakers, rated 7.5 kv., 400 ampere interrupting capacity 30,000 kva. The circuit breakers are controlled from the switchboard substations. Space above the operating mechanism provides for instruments, relays, reclosing timer, control switch, etc., converting the units to full-automatic and self-contained if required. Front and rear doors give ready access to all parts for inspection. Manual, d-c. solenoid, a-c. and d-c. trip-free motor mechanisms are available. The houses are compact, well constructed, low in first cost and maintenance.

**W. M. Bailey Now Chief Engineer of Dubilier Condenser Corp.**—William Mason Bailey, formerly with the Wireless Specialty Apparatus Company, of Boston, has been appointed chief engineer of the Dubilier Condenser Corporation in New York City. In collaboration with William Dubilier and the engineering staff of the organization, Mr. Bailey has in large measure been responsible for recent Dubilier developments such as the standard unit oil condenser, the moulded micadon, the ultra high frequency capacitors and the improved electrolytic condensers.

# Trade Literature

**Illumination.**—Bulletin 31F16, 8 pp., entitled, "Most Efficient Lighting for Schools and College." Holophane Company, Inc., 342 Madison Avenue, New York.

**Electrical Sheets.**—Bulletin, 12 pp. Describes "Armco" electrical sheet steel grades for motors, generators, and transformers. The American Rolling Mill Company, Middletown, Ohio.

**Lead Tantalum Rectifiers.**—Catalog TC-37, 16 pp. Describes Fansteel lead tantalum rectifiers for battery charging and direct-current power. Fansteel Products Company, Inc., North Chicago, Ill.

**Belt Conveyors.**—Booklet, 24 pp. An interesting, largely pictorial presentation of the use of belt conveyors for coal handling and transportation of raw materials in many fields. The Diamond Rubber Company, Inc., Akron, Ohio.

**Motors.**—Bulletin 174, 22 pp. Describes seven types of squirrel cage motors, including application tables, speed torque curves, and complete construction details. Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis, Mo.

**Aluminum Alloys.**—Booklet, 64 pp., "Alcoa Aluminum and Its Alloys." The book gives in concise form the physical and mechanical properties of the alloys produced by the Aluminum Company of America, Pittsburgh, Penna. Included are tables showing sizes of the basic commodities the company manufactures from these alloys.

**Ventilating Propeller Fans.**—Catalog, 48 pp. Describes Ilg self-cooled motor propeller fans. Contains numerous illustrations depicting applications in homes, garages, factories, etc. Ilg Electric Ventilating Company, 2850 No. Crawford Avenue, Chicago.

**Monel Metal Bolts.**—Bulletin T-1, 8 pp. A technical exposition of the properties of Monel Metal bolts which, among other applications, are extensively used in outdoor electrical installations because of their strength, ductility, and resistance to corrosion. International Nickel Company, Inc., 67 Wall Street, New York.

**Self-Tapping and Drive Screws.**—Catalog, 30 pp. Describes self-tapping screws, drive screws, and screw nails for joining and making fastenings to sheet metal, bakelite, slate, etc. Such screws are widely used in the assembly of radio receivers and by electrical manufacturers for fastening cleats and other wire devices, instruments, number plates, etc. to slate, ebony, asbestos, and other type switchboard panels. Parker-Kalon Corporation, 200 Varick Street, New York.

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## This Month—

### Front Cover

The East River at dusk, a less familiar portion of New York City's widely publicized skyline, showing the Waterside steam-electric generating stations of the New York Edison Company (6 stacks), one of the plants of the New York Steam Corporation (tallest stack), and a glimpse of three of the financial district's monuments in the background.

Photo by Samuel H. Gottscho, Jamaica, N. Y.

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DEVELOPMENT of a high degree of reliability in the low-voltage a-c. network required the development of a network protector having special characteristics. Various methods of obtaining these characteristics are used by the different manufacturers. *p. 307–312*

MORE ACCURATE calculation of conditions on power systems after the occurrence of a fault now can be made by the use of revised standard decrement curves developed jointly by General Electric and Westinghouse engineers. *p. 324–329*

ELIMINATION of a series of severe arc-overs caused by lightning surges entering a distribution substation has been secured by shunting low voltage lightning arresters across the regulator series winding and by connecting lightning arresters at the substation end of the entrance cable. *p. 304–306*

CLEVELAND, Ohio, "the forest city" situated on the south shore of Lake Erie, will be host to the summer convention of the Institute June 20–24, 1932. In addition a most complete technical program, many vacation features and novel entertainments are being arranged. There will be no registration fee. *p. 346–348*

MANY interesting discussions took place at the recent meeting of the Institute's Great Lakes District in Milwaukee, Wis., March 14–16, 1932. The principal of these are summarized in this issue. *p. 348–350.* The concluding section of summaries of winter convention discussions also is given. *p. 350–353*

INTEREST in the "Letters to the Editor" section is constantly growing, and members are taking advantage of this opportunity to express themselves briefly and informally on a variety of topics. *p. 354–355*

ONE ASPECT of the banking and investment situation is stated clearly in an editorial recently printed in *Engineering News-Record*. Bankers, it is claimed, are responsible for the failure of many investments abroad, due to their unwillingness to take advantage of expert engineering advice. *p. 353–354*

GAS FILLED tubes have characteristics which make them adaptable to many rectifier, inverter, and control applications. Also, the capacity of the electron tube has been increased manyfold by filling with gas or vapor, and the sensitivity by which these tubes may be controlled is being developed constantly. *p. 312–318*

THE PART that engineering and engineers may play in the stabilization of industry is discussed in the tenth article in the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?" contributed by William Green, president of the American Federation of Labor. *p. 318–319*

AN INNOVATION has been introduced by the use of alternating current for the operation of supervisory control systems. Furthermore, these systems may possess great reliability, and arrangements may be made for the operator to visualize switching conditions at a glance. *p. 329–331*

ELECTRICAL and magnetic units are being subjected to careful scrutiny at all times; they are discussed in four articles presented in this issue. *p. 335–345*

PARAGUTTA, an improved insulating material for submarine communication cables, has made it possible to obtain three telephone channels in a cable but little larger than the older single-channel gutta-percha cables. *p. 332–335*

OPEN-CIRCUIT remanence of a permanent magnet and the manner in which it is affected by various factors is a study of prime importance to magnet manufacturers and users. These factors include the magnetic properties of the steel itself and the shape and size of the magnet, all of which can be controlled in the design and manufacture. *p. 320–323*

# Weather Resistant Covering for Line Wires

**Previous to the last two years, development of weather resistant covering for line wires lay in the hands of the manufacturer and was centered upon meeting the demand for a cheaper product. This resulted in a decreasing life of the covering. Research described in this article points the way to a greatly improved covering which, although slightly more expensive to produce, can be justified economically by its longer life and higher insulating quality. Specifications for the saturant of such a covering are presented herewith.**

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DURING the years following 1918 or 1920 effort was concentrated upon the reduction of cost of weather resistant covering for line wires. This resulted in the early loss of saturating compound and the shedding of braids, in many cases within a period of two or three years after the erection of the lines. Sentiments of many operating engineers therefore swung toward discontinuing a weather resistant covering on overhead lines and adopting bare conductors for all service except where tree wire was necessary or where highly insulated conductors were required at points of inadequate spacing or clearance.

Certain engineers opposed the policy of abandoning the use of weather resistant coverings on overhead lines having a line-to-line voltage of 4,000 or less, for the reason that such a covering might reduce the number of service interruptions by preventing grounds and short circuits. This group believed that an attempt should be made to improve weather resistant coverings before making a decision to discontinue their use. At the suggestion of engineers in the group of companies represented on the Utilities Research Commission, the latter initiated a study at Purdue University to develop weather resistant wire covering providing longer life and higher insulating value. This study was started October 1, 1929, under the direction of the electrical division of the engineering experiment station with the chemical division cooperating. Work already completed enables the following definite conclusions to be drawn:

1. The present triple braid weatherproof wire covering may be materially improved by using as saturants higher fusing-point blown asphalts, free of waxes, and of low boiling fluxes. Such saturants will provide a covering of uniformly long life.
2. These improvements can be secured at only a slightly increased cost.
3. The higher saturating temperatures required to apply such saturants may be used without damage to the cotton yarns and without excessive annealing of the copper conductors.
4. As a result of this work, a preliminary specification for the saturant of weatherproof coverings is presented in this article, and includes terms which guarantee weatherproof wire of long life.
5. Future work will provide a covering of lighter weight and smaller size, but of higher insulating value and longer life than present construction.

Economic studies have proved that these results justify an increased cost of weather resistant wire covering, provided the improvements of higher insulating value and longer life now available are incorporated during manufacture.

### Preliminary Specification for Weatherproof Wire Saturant

The saturating compound shall consist of a pure blown petroleum asphalt and shall not be mixed with any material such as paraffin, wax tailings or fluxes. It shall have the following physical properties:

**Ball and Ring Fusing Point:** 180–200 deg. fahr.

**Penetration:** 77 deg. fahr., 100 g., 5 sec., 35 or harder, tenths of mm.

**Pliability:** A mold of the asphalt $^1/_4$ x 1 x 4 in. shall not break when subjected to an angle of bending of 15 deg. around a mandrel of $^3/_{16}$ in. radius at a temperature of 0 deg. fahr. This test shall be made in the Reeve and and Yeager pliability testing equipment, at a rate of bending of 10 deg. per min.

**Loss by Evaporation:** A 100 g. sample of the compound heated for 100 hrs. at a temperature of 325 deg. fahr. shall not lose more than 1.0 g. in weight.

**Rise in Fusing Point:** The difference in the ball and ring fusing point determined before and after the above heating test shall not be greater than 40 deg. fahr.

**Change in Penetration After Heating:** The penetration of the sample subjected to the above heating test shall not become harder by more than 10 points. The crust formed on the sample during the heating test may be removed before determination of the penetration after heating.

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Written especially for ELECTRICAL ENGINEERING, based upon "Weather Resistant Covering for Line Wires" (No. 32-56) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932, and subsequently brought up to date by the inclusion of later test results and definite specifications. *Not published in pamphlet form.*

## LABORATORY EQUIPMENT

Complete testing equipment was purchased or constructed for the laboratory at the university, as it was found that no adequate equipment was available in the plants manufacturing weather resistant wire in the United States. Accelerated weathering equipment therefore was installed for testing the comparative length of life of completed wires, asphalts, and other saturants, yarns, etc.; this exposes the samples to light from a carbon arc and to a water spray at a constant wire temperature of 175 deg. fahr. during one part of the daily weathering cycle. The samples are subjected to freezing by moving the wire holding drum to a large refrigerator and to thawing and drying by moving back to the light exposure chamber. Distilled water is circulated to the sprays from a storage tank and pressure provided by an auxiliary pump.

A natural weathering rack for completed wires provides continuous current loading and application of line voltage to the wire samples. Service testing equipment for duplicating installation and service conditions includes apparatus for subjecting the wire to abrasion such as occurs when drawn over a crossarm or caused by rubbing on insulators, wrapping and bending at freezing temperatures, and for producing decentralization of the conductor in the covering as occurs in service.

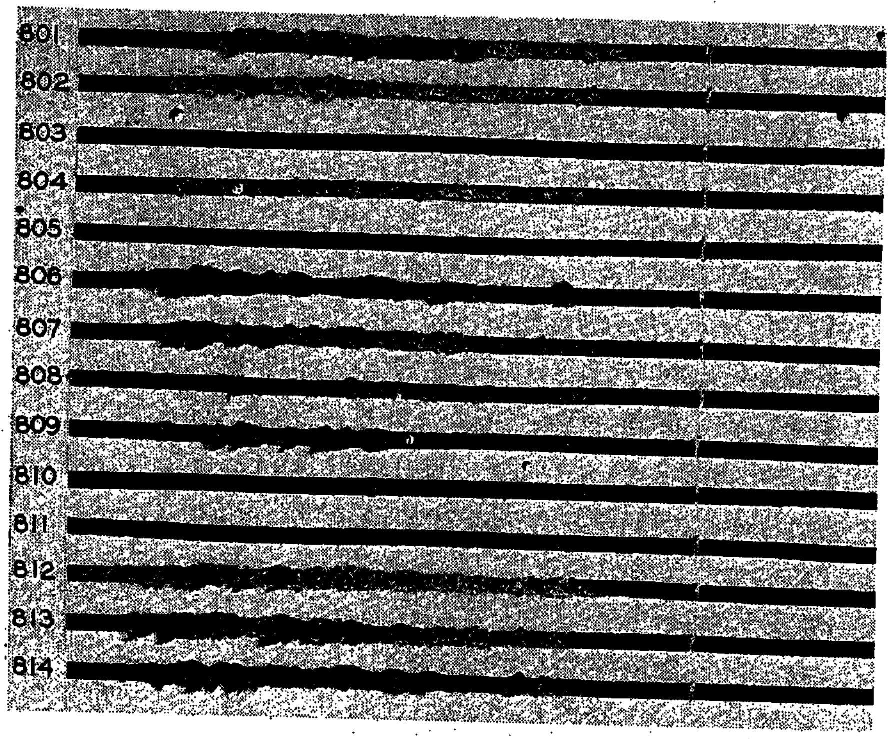

**Fig. 1. Condition after accelerated weathering test of wires saturated with commercial solvents**

Standard physical tests are applied to the saturant as follows:

1. Fusing point is determined by the standard ball and ring method used by the asphalt industry, the fusing point being the temperature at which a steel ball of specified weight drops through a mold of the material under test, the material being supported on a brass ring and immersed in water, the temperature of which is raised at a slow and definite rate.

2. Viscosity of the asphalt at saturating temperatures is determined by the Stormer method, by which it is expressed as the number of seconds required for 100 revolutions of a cylinder propelled by a 100-g. weight and immersed in the material to be tested.

3. Consistency or hardness is determined by use of the Abraham consistometer; this equipment measures the pressure required to force the various sized plungers at a constant rate into the mat under test. Hardness is also measured by the needle penetron commonly used by the asphalt industry. By this method the h ness is the depth of penetration into the asphalt, expressed in te of millimeters, of a standard needle with a weight of 100 g. ap for 5 sec. The lower the penetration number the harder is the terial. In Table I, hardness is expressed in terms of penetratio

4. Pliability at low temperatures is determined by bending a m of dimensions $^1/_4 \times 1 \times 4$ in., broadside about a round man $^3/_8$ in. in diameter while the sample and apparatus are held at low temperature of test. The angle of bend is increased at the of 10 deg. per min. and the angle of bending required to break mold is taken as a measure of the pliability.

The designs for an improved Abraham consistor ter to measure hardness, and for Reeve & Yea pliability test equipment especially adapted to t work, have been completed. The rate of penet tion in the consistometer and the rate of bending the pliability tester will be quite constant, as b are to be electrically driven and the degree of bendi in the pliability test will be determined by automa electric timing of the start and finish of the bendi period. The consistometer hardness will be re from a pressure gage which indicates the pressu on the table of the consistometer supporting t asphalt sample under test.

In the testing of finished wire a small electrical heated braid press and a pliability tester in whi very small samples of asphalt may be tested ha both been completed. The braid press is used extract the saturant from the two inner braids of finished wire. Sufficient asphalt is obtained from 2-ft. length of No. 6 wire for the standard ball a ring melt point test and the penetration determin tion. With this new equipment the pliability te can be made upon the small sample extracted fro the braids.

The commonly used drip and stain tests cann be regarded as tests of the physical properties of t saturants. The high melting wax used as an out coating prevents staining, and the yarns hold t asphalt, preventing dripping even though t saturant may be quite soft. The drip test ma favor also an unsaturated wire.

## PREVIOUS PRODUCTION METHODS

Before the start of the last decade, weathe proof wire coverings usually were built up of braid made from high-strength long-fiber cotton yar often saturated after each braid was applied an usually saturated with natural asphalts rather tha petroleum base asphalts. Production methods wer slow and the materials used more expensive than i is now possible to use. With the start of the las decade the producers of weatherproof wire began t use cheaper grades of cotton yarn and looser braids and for saturants they turned to petroleum by product asphalts. They further changed from th saturation of each braid after its application to th application of all three braids in one step and th saturation of these braids as a second step. To obtain the production speeds required and to saturat three braids in one step at the temperature (that o low pressure steam) available in the wire plants the use of low melting point petroleum asphalts of low viscosity at saturating temperatures became general.

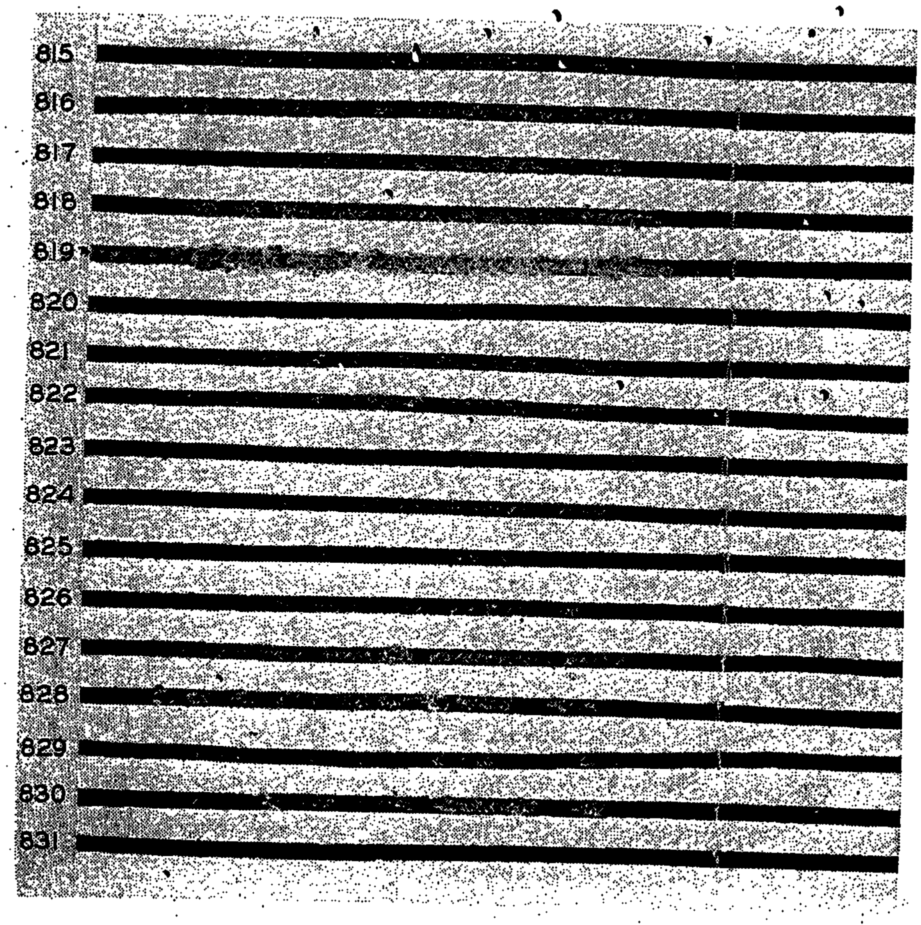

**Fig. 2. Condition after accelerated weathering test of wires meeting various parts of preliminary specifications. Wires 815–8, 820–6, and 830 meet these specifications in every detail**

## SATURANTS CAUSE OF MAJOR FAULTS

The test results indicate positively that the poor physical properties of the saturants used in weather resistant wire coverings in the past have been the cause of the extremely early failure of weather resistant wire. The coverings of wires which last well are eventually caused to fail by a combination of physical changes such as the shifting of saturants in the coverings, etc., and chemical changes in the saturant caused by exposure to light, oxygen of the air, etc. In very early failures the effects of light and oxygen are of less importance than the effects of poor physical properties which cause the saturant to shift in the braid when hot, and to crack and split when cold.

These poor physical properties of the saturants are: too low fusing points, extreme softness when warm, great changes in hardness with changes in temperature, extreme brittleness at even moderately low temperatures, and a marked tendency to evaporate. The majority of saturants used have had softening points (as determined by the ball and ring method) ranging from 130 to 150 deg. fahr., which are lower than maximum wire operating temperatures. These materials shift in the braids leaving the upper braids unprotected at ordinary summer temperatures, which are well below the fusing point. The extreme brittleness of these saturants, resulting in cracking and breaking of the braids in cold weather, may be illustrated by the fact that in the pliability test at 0 deg. fahr., less than 2 deg. bending is required to break the molds of the majority of these saturants.

Many of the poor physical properties, particularly the disappearance or evaporation of the saturant from the braids, have been caused by the addition of excessive amounts of waxes, wax tailings, or low melting fluxes to obtain fluidity and ease of saturation. Usually this addition was made by the workman operating the saturating tank and resulted in a saturant of variable properties. These low boiling materials soon leave the saturant, causing the body of the asphalt to disintegrate. The saturants vary in their resistance to the weathering effects of light and oxygen, and the worst are subject to excessive surface deterioration and erosion. The result of all these factors is the loss of compound, particularly from the upper side of the braids, with the resultant breaking of the braids on the upper side and the familiar festooning.

Finishing waxes cannot be regarded as of great protection to the covering because they evaporate or crack and flake off within a short time, or are damaged in installation. On the various samples in the natural exposure rack, the wax has cracked, chipped off, or simply disappeared from the surface of the wire in from 3 to 8 months.

## COTTON YARNS

It has been found that the cotton yarns are not so important in producing a long-lived covering as are the saturants. It is important, however, that sufficient cotton to absorb and hold the saturant be present in the two inner braids, and that the outer braid be closely woven to resist abrasion and erosion. The one fault of the braided construction is that because of the interstices always present it does not consistently afford insulation beyond that of the air spacing provided. It is desirable to have a more solid and homogeneous material next to the conductor.

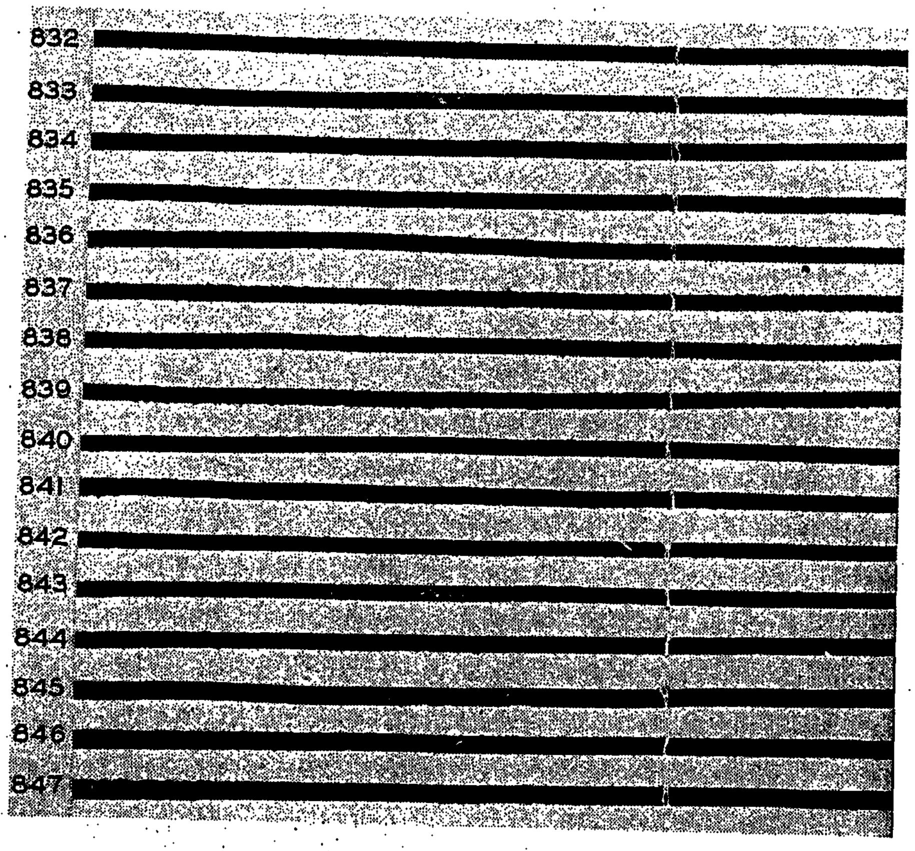

**Fig. 3. Wires illustrating the improved weather resistance of air blown asphalts to which the proper inert mineral fillers have been added**

Table I—Comparison of Physical Properties of Commercial Saturants and Asphalts Proposed as Saturants

| | Range of Physical Properties | | Average of Physical Properties | |
|---|---|---|---|---|
| | Commercial Saturants | Proposed Saturants | Commercial Saturants | Proposed Saturants |
| B. & R. fusing point | | | | |
| Before heating | 119–158°F | 186–208°F | 143.2°F | 196.1°F. |
| After heating | 176–245 | 209–232 | 198.4 | 220.7 |
| Penetration: 77°F., 100 g., 5 sec. | | | | |
| Before heating | 3–66 | 21–33 | 25.5 | 27.5 |
| After heating | | | | |
| with crust | 0–23 | 0–4 | 8.7 | 1.0 |
| crust removed | 0–26 | 17–29 | 11.8 | 22.3 |
| Loss in weight during heating | 0.12% gain, 7.17% loss | 0.03–0.97% loss | 1.63% | 0.36% |
| Pliability | 0.41°–13.3° | 16.2°–48° | 3.21° | 26.5° |
| Specific gravity | | | | |
| Before heating | 1.001–1.200 | 0.987–1.044 | 1.071 | 1.011 |
| After heating | 1.021–1.208 | 0.988–1.042 | 1.080 | 1.013 |

## IMPROVED SATURANTS

The use, as weatherproof wire saturants, of the air blown asphalts meeting the preliminary specification which has been developed, has been proved in the laboratory to yield a greatly increased length of life of the covering on any size of wire over that provided by the usual commercial saturants, and to provide a great increase of flexibility in the finished wire. The physical properties of these asphalts and the present commercial saturants are given in Table 1. The preliminary specification also is given on p. 299.

Such an asphalt, of greater stability at higher wire temperatures, will reduce materially the shift of the saturant in the braids and will be less subject to evaporation and erosion. In addition, these asphalts are less susceptible to temperature changes and are much less brittle at low temperatures. Such asphalts may be bent many degrees in the pliability test, while most commercial saturants cannot be bent more than 2 deg.

These "air blown asphalts" are produced by blowing air through the heated petroleum residue, as compared to the production of the usual commercial saturant by blowing steam through the petroleum residue. Certain changes in the structure of the asphalt are produced by the air blowing which results in a much more stable asphalt of lower temperature susceptibility. The asphalts illustrated in Fig. 2 are stock products; they are not special materials in any sense. There is no reason to think that the increased use of air blown asphalts meeting these specifications will result in a marked increase in cost of the materials (which now cost very little more than the steam reduced asphalts) because the petroleum residue is just as readily blown to meet this specification as one of a lower melting point.

Adequate proof of the betterment obtained by the use of these materials is given by comparing the wires in Fig. 1 with those in Fig. 2, all having had the same exposure in the accelerated weathering test. Fig. 1 shows the condition of wires saturated with the present commercial saturants after having been exposed in the accelerated weathering test at Purdue. The four wire coverings that have held up well on this test are saturated with very hard and very brittle materials. The asphalts with which these four wires are saturated bend less than 2 deg. in the pliability test. This emphasizes the importance of applying both the laboratory pliability test and the accelerated weathering test in choosing the most satisfactory weather resistant coverings. The wires in Fig. 2 have coverings saturated with air blown asphalts meeting the specification for melting point and penetration, but in the case of samples 819, 826–9, and 831 not meeting other parts of the specification such as those for pliability or changes in physical properties with long continued heating. It may be seen readily that the wires meeting the preliminary specification in every detail provide a vast improvement in weather resistance over the commercial saturants; these wires are numbers 815–8, 820–6 and 830. In the pliability test all of these asphalts bend more than 15 deg. and wires saturated with these materials may be bent about their own diameter at freezing, or lower in some cases, without breaking any of the braids.

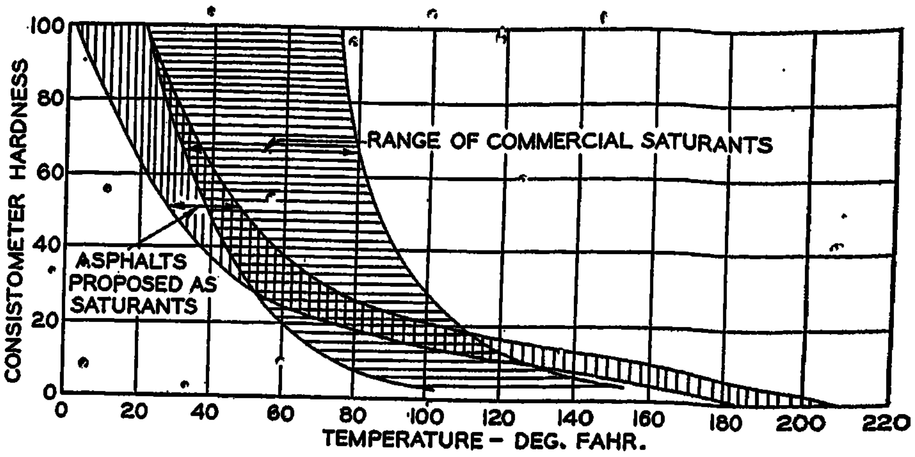

Fig. 4. Comparison of initial hardness

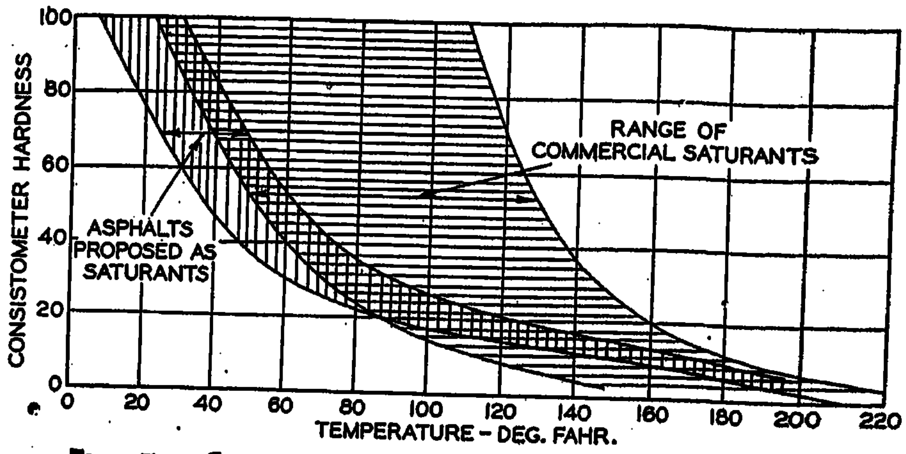

Fig. 5. Comparison of hardness of saturants after heating for 100 hr. at 325 deg. fahr.

Sample 819 is saturated with a material that has shown peculiar breakdown when exposed to light and heat and that has been used in the lower melting point ranges in very great quantities of weatherproof wire in the past 10 years.

The use of the asphalts meeting the preliminary specification requires only a change of saturating temperature and does provide a remarkable improvement in the weather resistance of the covering.

The smaller change with temperature in the hardness of air blown asphalts as compared with the commercial saturants, and also the greater stability at the higher operating temperatures, is illustrated in Fig. 4. It may be seen that the air blown asphalts are harder, as an average, at temperatures of 40 deg.

fahr. and higher; but are softer than the commercial saturants below this temperature. The smaller change in the hardness of the air blown asphalts as compared with the commercial saturants after being heated for 100 hr. at 325 deg. fahr. is shown in Fig. 5. It will be noted that the blown asphalts have not changed greatly, while the commercial saturants have become much harder. This lack of change with long heating has been proved to correlate rather closely with the resistance of the wire covering to weathering.

While all of the asphalts which weather poorly in the wires in Fig. 2 would have been eliminated by requiring them to meet the preliminary specification, it is not yet certain that this will always be true and the accelerated weathering test must still be depended upon to eliminate the poor materials. In the operation of the "weatherometer" on the standard cycle used by the Bureau of Standards, the commercial saturants all show extreme checking or cracking in only one day whereas the asphalts recommended show no signs of deterioration in this time except in one instance, thus checking the tests of the asphalts in wires as illustrated in Figs. 1, 2, and 3.

The analysis of asphalt and the determination of chemical unsaturation now are being carried on to learn if it is possible to correlate some result of this analysis with the variation in weathering.

## SATURATING TEMPERATURES

To obtain thorough saturation of triple braid coverings with saturants of a fusing point of from 180 to 200 deg. fahr. at present saturating speeds, it is necessary to use higher saturating temperatures than are used today. Laboratory tests have shown that to obtain saturation of three braids on No. 6 AWG. conductors in 5 min. requires a saturant viscosity of 100 deg. Stormer, or less. In Fig. 6 is shown graphically the time required to saturate at any given viscosity the triple braid covering on No. 6 AWG. conductors with asphalts of a very wide range. It should be noted that the time of saturation is not the same for all saturants at a given viscosity but varies with the asphalt, some requiring more and some less time.

That higher temperatures are required to obtain saturation of the braided coverings with the air blown asphalts than are required in the case of the commercial saturants is shown in Fig. 7. Viscosities lower than 100 sec. per 100 revolutions are required to obtain saturation of triple braid coverings at present saturating speeds, and temperatures of 360 deg. fahr. and higher are necessary for saturation with these asphalts. A change would be required in the heating equipment for the saturating tanks if such saturants are to be used.

A number of tests was made to determine definitely whether or not saturating temperatures as high as 400 deg. fahr. can be used without damaging the cotton yarns or too greatly annealing the copper conductors. The cotton yarns were tested for tensile strength, heated in air for different times, allowed to regain normal moisture content, and again tested. The tensile strength of oil soaked yarns was also tested and compared with that of similar yarns heated in oil for varying times. No. 6 AWG. copper conductors, both medium hard and hard drawn, were tested for tensile strength after heating in hot oil for varying times, and compared with tests made on unheated conductors. The results of the cotton and copper tests are presented in Tables II and III.

It may be seen that the loss of strength of the cotton yarn is of no importance in even the longest saturating time. There is no appreciable annealing of the copper conductors in the saturating times required in the modern continuous saturating tanks now generally used. In the case of the older type

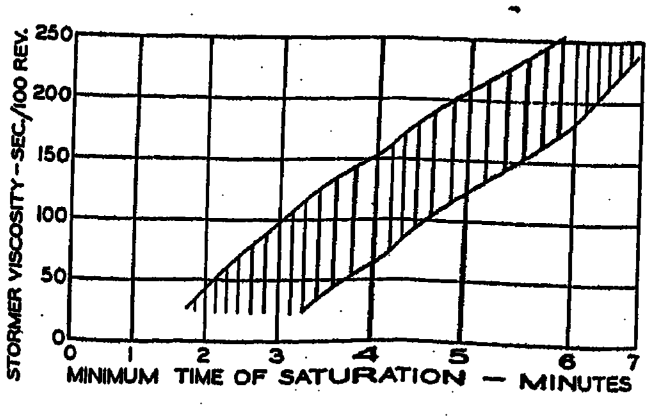

Fig. 6. (Left) Viscosity vs. saturating time for triple braid covering on No. 6 AWG. conductors

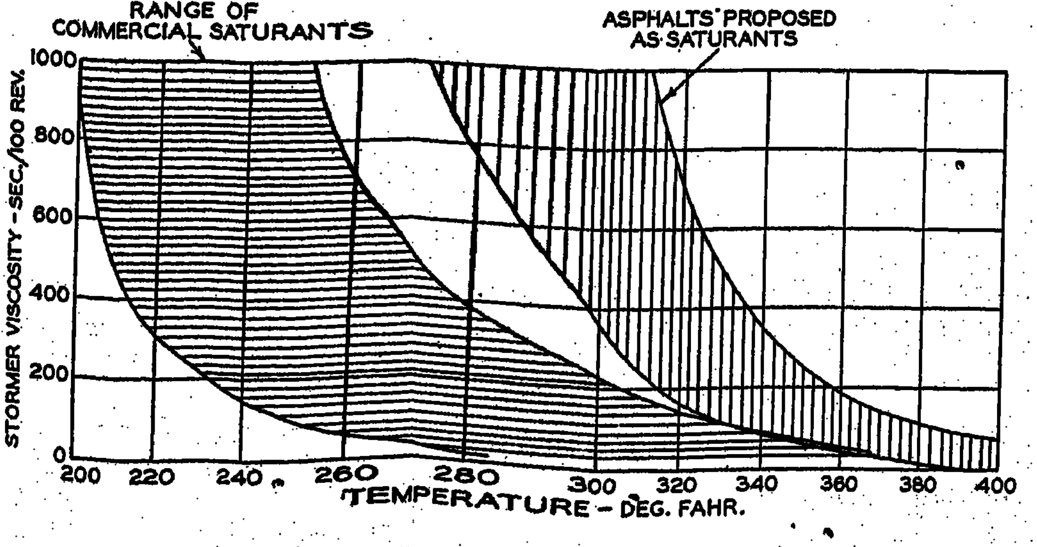

Fig. 7. (Below) Comparison of viscosity of saturants

**Table II—Effect of Saturating Temperature on the Tensile Strength of Cotton Yarn**

Yarn Heated in Air (Constant Temperature Oven)

| Sample | Tensile Strength | Loss | Per Cent Loss |
|---|---|---|---|
| Original yarn | 2,001 g. | | |
| Heated 15 min. at 392 deg. fahr. | 1,760 g. | 241 | 12.0 |
| Heated 30 min. at 392 deg. fahr. | 1,526 g. | 475 | 23.7 |
| Heated 90 min. at 392 deg. fahr. | 1,360 g. | 641 | 32.0 |

Yarn Heated in Oil

| Sample | Average Tensile Strength | Per Cent Loss | | |
|---|---|---|---|---|
| | | *A* | *B* | *C* |
| Dry yarn | 1,908 g. | | | |
| Dipped in cold oil | 1,917 g. | | | |
| Heated 15 min. 212 deg. fahr. | 1,809 g. | 5.62 | | |
| Heated 30 min. 212 deg. fahr. | 1,731 g. | 14.5 | 4.32 | |
| Heated 15 min. 302 deg. fahr. | 1,683 g. | 12.2 | 7.00 | |
| Heated 30 min. 302 deg. fahr. | 1,623 g. | 15.3 | 10.30 | 3.57 |
| Heated 7¹/₂ min. 392 deg. fahr. | 1,637 g. | 14.6 | 9.55 | 2.52 |
| Heated 15 min. 392 deg. fahr. | 1,593 g. | 16.85 | 11.98 | 5.35 |
| Heated 30 min. 392 deg. fahr. | 1,546 g. | 19.3 | 14.55 | 8.13 |

*A* Cold oiled sample as a standard
*B* Sample heated 15 min. at 212 deg. fahr., as a standard
*C* Sample heated 15 min. at 302 deg. fahr., as a standard

**Table III—Effect of Saturating Temperature on the Tensile Strength of Copper Conductors**

All Samples Heated at 392 Deg. Fahr.

| Kind of Sample | Tensile Strength Lb. per Sq. In. | Loss in Strength Lb. per Sq. In. | Per Cent Loss |
|---|---|---|---|
| Hard drawn No. 6 copper wire | | | |
| Unheated wire | 63,560 | | |
| Heated 10 min | 62,590 | 970 | 1.53 |
| Heated 30 min | 61,140 | 2,420 | 3.96 |
| Medium hard drawn No. 6 copper wire | | | |
| Unheated wire | 51,430 | | |
| Heated 10 min | 50,780 | 650 | 1.27 |
| Heated 30 min | 49,490 | 1,940 | 3.93 |

"reel in and reel out" saturating tank, the time required for saturating may be long enough to anneal the conductor slightly, requiring that the conductors be drawn somewhat harder initially. It is believed that these tests have definitely cleared the way for the use of higher saturating temperatures in so far as a likelihood of any damage to yarns or conductors is concerned.

### OTHER MODIFICATIONS

The improvement that may be made in the weather resistance of the air blown asphalts by the use of the proper inert mineral filler is shown in Fig. 3. Wires numbers 832–5 are saturated with the same materials as wires 815–8 in Fig. 2 except that 30 per cent by weight of 325-mesh slate dust was added to the asphalt before saturation. Wires 840–2 in Fig. 4 are also asphalts to which certain modifying agents have been added. The use of such modifying materials provides an additional and very desirable improvement in the weather resistance of the wire covering and also may slightly reduce the cost of the saturant because of the cheapness of the slate dust. The use of the filler is particularly helpful in the case of the asphalt on the surface of the wire and in the case of the finishing materials.

Finishing materials that are more flexible than the present waxes may be had and are much more desirable, particularly when some filler is used as a coating or an anti-stick in these finishes. Mica flake is especially valuable as an outer finish.

### NEW AND IMPROVED COVERINGS

The greatly superior insulation of paper tape covered samples with a single weatherproofed outer braid has been shown repeatedly by the slower decrease in insulation resistance of this covering when immersed in water, as compared with the triple braid construction. The use of this paper tape and single braid covering provides a conductor of lighter weight and of much smaller overall diameter, which means that sleet and wind loads will be lower, and also that the conductor will possess consistently high dielectric strength even with considerable exposure of the braids to the weather. Bakelite and other synthetic resins, Harvel compounds and varnishes, and other materials, have been applied to weather resistant wire coverings, and because of the excellent weathering quality of such materials provide a highly protective coating.

Ample proof has been given that the materials recommended herewith will produce longer life in weatherproof wire coverings. Also, these materials may be obtained within a reasonable distance of any weatherproof wire plant in the United States. It is felt that the experience and equipment built up as a result of this work should prove of value in the development of improved weatherproof braids as applied to types of wire other than the ordinary weatherproof wire. This is especially apparent when it is pointed out that in looking for improved materials, the coverings of tree wires and other insulated overhead line wires were investigated to learn if the weatherproofing compounds used in the braids on these wires were superior to the ordinary weatherproofing compounds, and it was discovered that while these coverings were made of exceptionally strong and high grade braids, they were not saturated with compounds in any way superior to the present commercial weatherproof saturants.

# Impulse Tests on a Substation

**Severe flashovers have occurred in ungrounded 4,800-volt distribution substations in Detroit. Impulse tests have proved that these were caused by surges reflected from regulator windings, but can be prevented by the proper placing of lightning arresters.**

By

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DURING the 1928 lightning season the Detroit Edison Company experienced in five substations a total of six arc-overs which were caused by

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Based upon "Impulse Voltage Tests on a 4,800-Volt Distribution Substation" (No. 31-133) presented at the A.I.E.E. South West District meeting, Kansas City, Mo., October 22–24, 1931.

lightning voltages entering the stations by way of a 4,800-volt ungrounded distribution system. The overhead lines of this system enter the substations through three-conductor underground cables, and lightning arresters are located at each junction of line to cable and at the substation bus. Some of the distribution lines are equipped with three phase voltage regulators in the substations. These regulators are *Y*-connected, but the neutral is not brought out and is insulated from ground. Fig. 1 shows the layout of a typical distribution line with a regulator.

Besides being unusually large in number for a single season, the arc-overs were of unexpected severity. In each case the lightning voltage causing flashover entered the substation by way of a distribution line on which there was a voltage regulator. Furthermore, the flashovers occurred at some point between the substation pothead and the line-side regulator terminals, their nature indicating that they were caused by potentials in excess of the breakdown voltages of the cable pole and bus lightning arresters, which inspection showed to be in good operating condition. This consistency in the location of the flashovers indicated that the surge impedance of the regulator series winding probably was great enough to cause reflections of surges entering the substation, and so to result in the building up of a voltage at the regulator line terminals sufficiently high to cause flashover.

As the result of a series of impulse voltage tests, two forms of protection were found to be effective in preventing the surge voltage rising to values sufficient to break down the entrance cable or cause flashovers at the station end. Low voltage lightning arresters shunted across the regulator series windings operate in series with the bus arrester and limit to the sum of the breakdown voltages of these two sets of arresters the rise of voltage on the line side of the regulator. The second method, and the one which is more desirable because of its insuring a lower voltage at the substation end of the cable, is to connect arresters at this point to ground. They limit the voltage on the substation pothead and on the regulator, and, acting in combination with the arresters on the bus and at the outside end of the cable, the voltage in the station and entrance cables to the drops across the arresters.

## EQUIPMENT USED

The 4,800-volt Elmdale distribution substation is of the open pipe-frame construction, the bus copper and all leads being insulated with varnished cambric. One distribution line with voltage regulator was left in the substation, and its 745-ft. entrance cable was looped back so that both ends were in the station. This was a three-conductor, 200,000-cir. mil, lead-covered cable insulated with oil-impregnated paper $^5/_{32}$ in. thick on the conductors with a $^5/_{32}$-in. over-all belt. A dead 24,000-volt three-conductor cable line 8,900 ft. long terminated in the station and was available during the tests.

The impulse voltages used during the various tests were obtained from a 1,000,000-volt lightning generator and auxiliary equipment. Since only 180,000 volts were required in the tests, the generator was reconnected to deliver this voltage with a capacity of 0.075$\mu$f. During the tests, two portable cathode-ray oscillographs were used, one being an improved Norinder oscillograph, and the other a George oscillograph of the hot cathode type. The apparatus in the measuring system included a resistance potentiometer and a delay cable.

The substation apparatus tested is shown in Fig. 1. Pothead 1 represents the cable pole pothead of the entrance cable. It was to this pothead that the surge generator was connected by a resistance, and through it the voltage surges entered the station. It will be noted that the three phases were joined electrically by potential transformers which were connected open-delta, and by the voltage regulator which was *Y*-connected with neutral ungrounded. Each phase had a lightning arrester at the cable pole pothead 1 and at a point on each bus section, 6 and 7; various combinations of these arresters were tried during the tests. The arresters were rated 6,000 volts for use on an ungrounded system. Suitable lightning arresters also were available for connection at the substation pothead and for shunting the regulator series winding.

An analysis of a traveling surge entering the cable from the overhead line shows that, due to the lower surge impedance of the cable, the wave on the line will be reflected with reduced magnitude and reversed polarity. The voltage of the surge entering the cable will be less and the current greater than in the original line surge. The following equations show these effects:

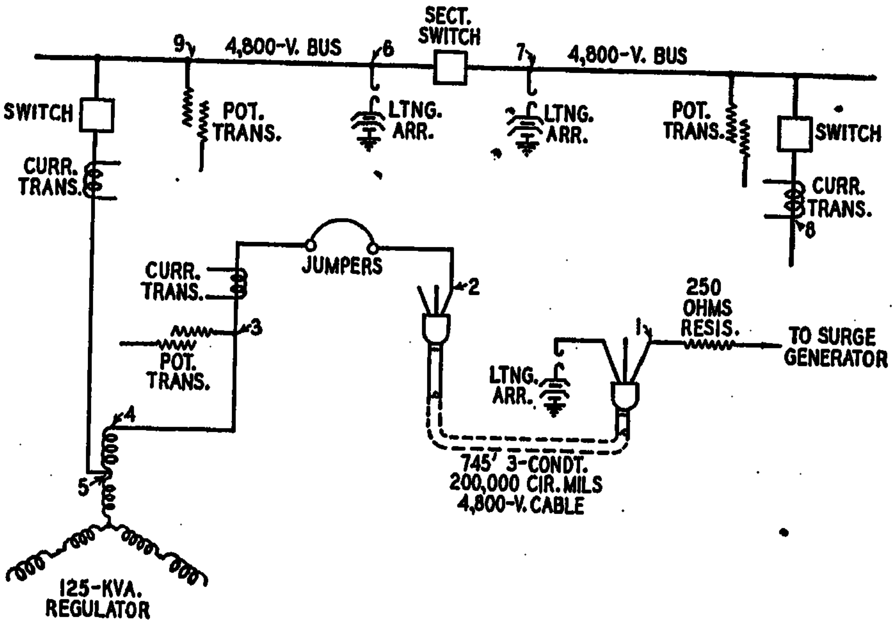

**Fig. 1. Typical circuit layout at Elmdale substation, indicating points at which oscillograms of the surge voltage waves were taken**

$$e = \frac{2Z_c}{Z_c + Z_L} E_L$$

$$i = \frac{e}{Z_c}$$

where

$e$ = voltage of surge in cable
$Z_c$ = surge impedance of cable
$Z_L$ = surge impedance of line
$E_L$ = voltage of surge on line
$i$ = surge current in cable

If the surge generator should be discharged directly into the cable, the current drawn by the arresters would be excessive due to successive reflections of current. Since it was not possible to apply the surge to the cable by means of an overhead line, a resistance was placed in series with the surge generator to limit the current in the cable to a value which would approximate that of a surge entering from an overhead line. In the tests a series resistance of about 250 ohms was used.

Two general types of impulse voltage waves were used. One had a wave front with voltage rise from zero to maximum in approximately one microsecond, while the other, which was secured by connecting 1,360 millihenrys inductance in series with the surge generator, had a wave front with voltage rise to maximum in about 10 microseconds. The wave having the steep front, as nearly as rectangular as possible, was required to show clearly on the oscillogram, reflections of the impulse at the voltage regulator. Tests with surges having the slower wave fronts were also desirable in order to determine the effects of moderate surges of voltage such as may be induced on lines by nearby lightning strokes.

In the preliminary tests it was found that a number of factors which might be considered to be of importance could be neglected. For example, oscillograms taken with various values of resistance connected to the bus to simulate the effects of other circuits indicated that although the surge voltage appearing on the bus decreased as the connected resistances were decreased, the shapes of the impulse voltage waves at points 1 and 2 were unaffected. Therefore most of the tests were made with the station bus open-circuited. It was found also that although in order to simulate connection to an overhead line the two phases which were not connected to the surge generator should be grounded at 1 through a resistance having a value of about 500 ohms the oscillograms did not differ from those taken with these phases open-circuited; consequently most of the tests were made with the latter arrangement. Preliminary voltage-time oscillograms also indicated that the effects of the instrument transformers were slight and that measurements need be taken only at positions 1, 2, and 5. At these three points the oscillograms are quite different because of the effect of the cable pole lightning arresters, the cable itself, and the voltage regulator. Also the voltages induced on the two phases which were not connected to the surge generator were found to be of negligible magnitude, or usually about one-fourth of the voltage on the surged phase. Therefore further measurement of them was omitted.

The impulse voltage tests indicated definitely that only a small amount of energy was drawn from the cable through the series windings of the regulator by the lightning arresters and other equipment connected to the bus, especially for the first part of the wave. In one test a surge of about 25-kv. crest entered the cable and was increased at station pothead 2 to a crest value of about 43 kv. by the partial reflection at the voltage regulator. The positive reflected wave returned to the cable pole end where it caused sufficient voltage rise to break down the lightning arresters located there. These arresters prevented further voltage rise and returned a negative reflected wave to the station end of the cable, reducing the voltage at that point to about 23 kv. Due to the high impedance of the regulator series winding, the rise of surge voltage on the bus was much lower than at the station pothead, and the bus lightning arresters were not able to protect the cable against voltage surges which may enter the substation through it. Additional tests made with the lightning arresters at the cable pole end disconnected also indicated that the lightning arresters on the bus do not provide protection for the cable, as the regulator impedance remained very high for a period sufficient to cause a flashover at the station pothead.

Using the slow-front wave, oscillograms were taken, but these did not show the reflections at the regulator as distinctly as did those for the steep-front wave, because the entering wave does not reach its maximum at the cable pole pothead before the reflection begins to return from the regulator and adds to the voltage of the entering wave. However, if the entrance cable had been long enough to require about 10 microseconds for an impulse to travel back and forth through it, then the reflections would have been just as distinct as for the surge having a one-microsecond front. These oscillograms do show definitely that the surge voltage at the regulator rises to a value greater than that at the cable pole pothead, and the reflections at the regulator are therefore appreciable. Consequently, even with the slow-front wave, the regulator series winding offers considerable impedance and the rise of voltage on the bus is slow.

The tests showed conclusively that the lightning arresters at the cable pole end of the entrance cable only partially limit the rise of voltage at the substation end of the cable. If the front of the incident wave is short and the entrance cable long, approximately double the voltage at the cable pole end will be impressed at the station end for an appreciable time before the cable pole arresters relieve this condition.

By these tests, however, it was definitely proved that the voltage at the station pothead may be limited to a safe value by shunting low voltage arresters across the regulator series winding, thus permitting the bus arresters to help lower the voltage at this point. The rise in voltage on the line side of the regulator then is limited to the sum of the breakdown voltages of these two sets of arresters.

It was also definitely proved that protection could be secured by lightning arresters located at the substation end of the cable. These limit the voltage on the pothead and the regulator, and, in combination with the cable pole and the bus arresters, limit the voltage in the cables within the station and in all of the entrance cables to the drops across the arresters. This method of protection is more desirable than the use of low voltage arresters shunting the regulator series windings, since lightning arresters connected at the station pothead limit the voltage at that point to a somewhat lower value.

# Operating Requirements of the Network Protector

**Rapid extension of the low-voltage a-c.* network in metropolitan areas has required the solution of a number of new problems, among them being the development of a suitable network protector consisting of circuit breaker, relays, etc., to disconnect the feeder from the network at the proper times.**

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RELAY PROTECTION of the type of low voltage a-c. network installed in the metropolitan area of New York City was designed to give the a-c. network the same reliability of service obtained on a d-c. network. Such reliability was essential if the a-c. network was to be used in areas of high load density where continuity of service is of paramount importance.

Briefly, this type of a-c. network consists of a grid of three-phase four-wire low-voltage mains to which power is supplied at suitable intervals by distribution transformers connected to high voltage feeders. To obtain diversity of supply, adjacent transformers are connected to different high voltage feeders which in turn are supplied by different generator bus sections. Connecting the low voltage side of the transformers to the network are automatic network protectors which are the only means of readily disconnecting the high voltage feeders from the network.

The network protector consists of a three-pole air circuit breaker, a motor or solenoid to close the breaker against the action of springs and gravity, two relays which control the closing and opening of the circuit breaker, and fuses in series with the circuit breaker contacts to give back-up protection.

Many years' experience with the d-c. network, supplemented by test data, indicated that with sufficient power available, faults on the network would burn clear. Thus, the first requirement of the protection scheme was that all sources of power remain connected to the network during network disturbances. The next requirement was for the circuit breaker to open immediately when a fault occurred on the feeder side of the protector, either on the feeder or in a transformer connected to that feeder. In order that a high voltage feeder might be taken out of service with a minimum amount of time and expense it was considered desirable that the protector open on transformer exciting current, as the station operator could then clear a feeder merely by opening the station breaker.

The closing operation also had to meet certain requirements: first, if the transformer is energized while the network is deenergized, the protector must close; second, if the network is energized but the transformer is deenergized, it must remain open; third, when both transformer and network are energized the protector must close when, but only when, the magnitude and phase relation of the transformer voltage with respect to the network voltage is such that after it has closed, power will flow to the network.

### DESIGN OF MASTER RELAY

To meet these requirements a relay usually referred to as the master relay, having three induction type, watt-hour meter elements, was provided. These elements consist of disks mounted on a single shaft between the poles of electromagnets. The connections of the Westinghouse and General Electric master relays are shown schematically in Figs. 1 and 2. Referring to the diagram of the Westinghouse relay, the lower pole of each magnet is magnetized by a potential coil, and the upper poles by either the current coils or the phasing coils. The current coils are connected to current transformers and are energized when the breaker is closed. The phasing coils are connected in parallel with the breaker contact and are energized when the breaker is open. The General Electric relay is similar except that the current coils are also the phasing coils.

The relay operates in the same manner as any directional relay. The interaction of the flux due to current in the potential coil with that due to current in either the current or phasing coils, causes the disks to rotate in one direction if the flow of power is toward the network, and in the opposite direction if the flow is toward the transformer. The relay has one moving contact actuated by the disk shaft, and two stationary contacts. Rotation of the shaft in one direction closes the closing circuit of the protector, and in the opposite direction, the tripping circuit.

When the protector is completely deenergized, the relay is held in the closing position by a spring. Because the potential coil is on the network side of the protector, no magnetic torque will be present when the transformer only is energized; and to cause a protector to close on a dead network, mechanical torque has been provided. When the network is energized but a feeder is deenergized, the protectors associated with it will remain open because current will flow through the phasing circuits to give, in conjunction with the potential coils, maximum opening torque.

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*Written especially for ELECTRICAL ENGINEERING and based upon a talk presented before the power group of the Institute's New York Section. *Not published in pamphlet form.*

Upon energizing the feeder the voltage across each of the circuit breakers of its associated protector becomes the vector difference between the transformer voltage and that of the network. The torque on the relay depends upon the relation of this so-called phasing voltage to the network voltage. It is desirable that the transformer voltage be somewhat greater in magnitude than the network voltage before the breaker is closed. To impose this limitation upon the operation of the relay, the potential coil flux is lagged by an adjustable shading coil or lag ring so that the potential coils alone exert an opening torque slightly greater than the closing torque of the spring. Before the relay will make its "closing" contacts this excess opening torque must be overcome by the phasing coils. The amount of phasing voltage necessary to close the breaker may be varied by adjusting the shading coils. Practise on the system of the New York and Queens Electric Light and Power Company is to set the relays to close when a phasing voltage of 2 volts exists in phase with the network voltage.

The lamps shown in the phasing circuits and usually referred to as phasing lamps are 15-watt 150-volt tungsten lamps. As tungsten has a high positive temperature coefficient, its resistance will tend to keep the current in the phasing circuit constant regardless of the voltage across it, and the coils can be made sensitive to phasing voltages of widely varying magnitudes.

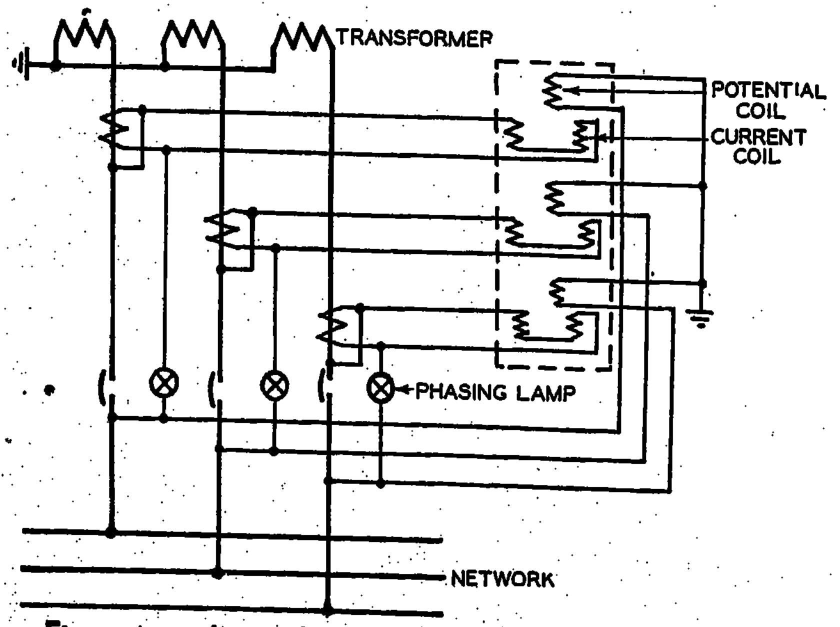
## OPERATING CHARACTERISTICS OF MASTER RELAY

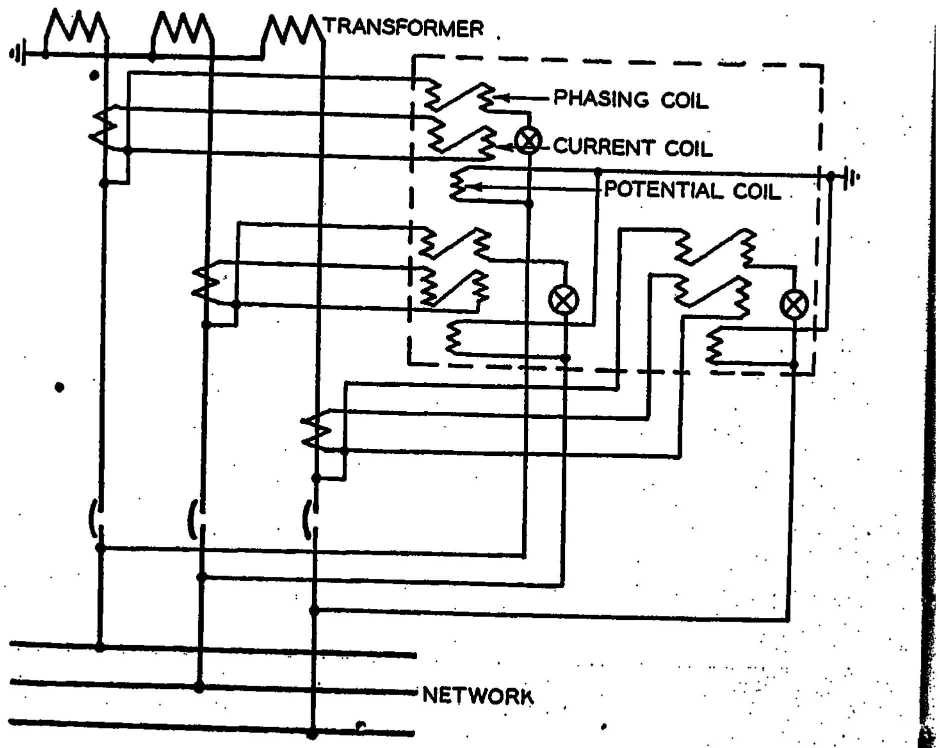
The operating characteristic of a Westinghouse master relay on a 1,600-ampere (submersible rating) protector is shown in Fig. 3. Curve 1 is the locus of line currents varying in magnitude and phase angle referred to the network voltage which will produce a balanced torque on the relay element. If a vector representing current of any given magnitude and phase angle drawn from the origin crosses the curve, that current will cause the relay to close its tripping contacts and the protector will open. If the vector of the current does not cross the curve, the relay will close its closing contacts. It is evident therefore that a current of 30 amperes lagging the network voltage, reversed, by 84 deg. will produce a balanced torque in the relay. As the exciting current of a 500-kva. three-phase transformer with which such a protector is used has an exciting current of approximately 30 amperes at an angle of less than 80 deg., as indicated by the vector $I_E$, the relay will cause the protector to open when exciting current only is flowing. Curve 2, which is curve 1 redrawn to a smaller scale, shows that for currents not exceeding 4,000 amperes the relay acts like the usual watt element, the characteristic being almost a straight horizontal line. When the current exceeds 4,000 amperes, the current transformers saturate and cause the curve to bend rapidly. This saturation protects the relay at high values of current in either direction. When saturation takes place, the ratio of the current transformers not only changes but the phase angle between the primary and secondary currents also changes. The primary current leads the secondary current less and less, with the result that the operating curve bends downward on the right-hand side and upward on the left-hand side. The upward bend improves relay operation on high values of short-circuit current but prevents the relay from operating on high values of charging current. This is indicated on the diagram, where the vector of charging current $I_c$ falls on the closing side of curve 2.

Closing curve 3 is the locus of vectors representing the magnitude and phase relation with respect to the network voltage, of transformer voltages which will produce a balanced torque in the relay. If the vector crosses the closing curve, the protector will be closed; otherwise it will remain open.

## DESIGN OF PHASING RELAY

When the high voltage feeders supplying a network are of different voltage and come from different





**Figs. 1 and 2. Schematic diagram of connections for General Electric master relay (above) and for Westinghouse master relay (right)**

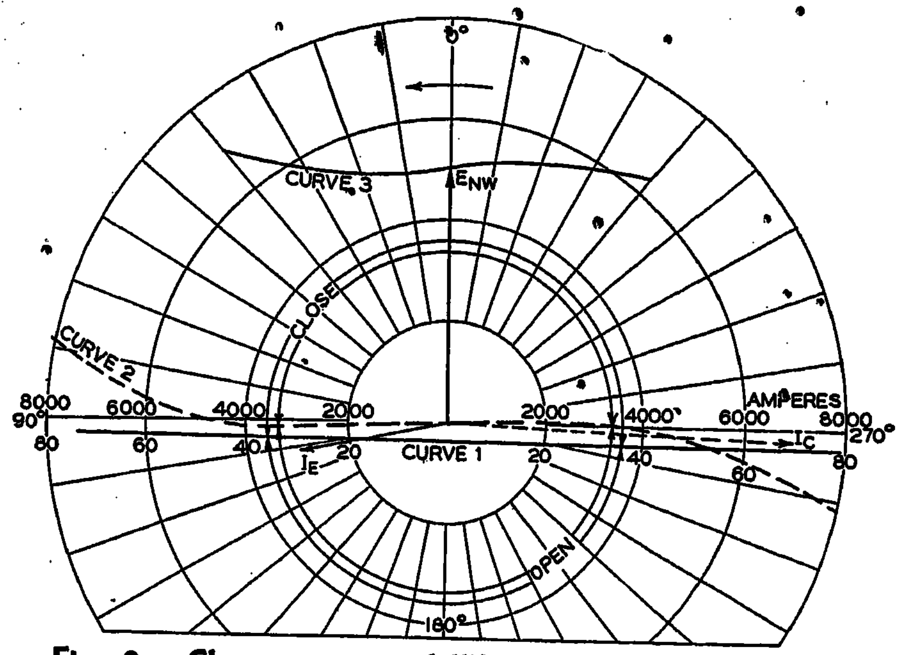


Fig. 3. Characteristics of Westinghouse master relay

For Curve 1 use lower ampere scale; for Curve 2, upper

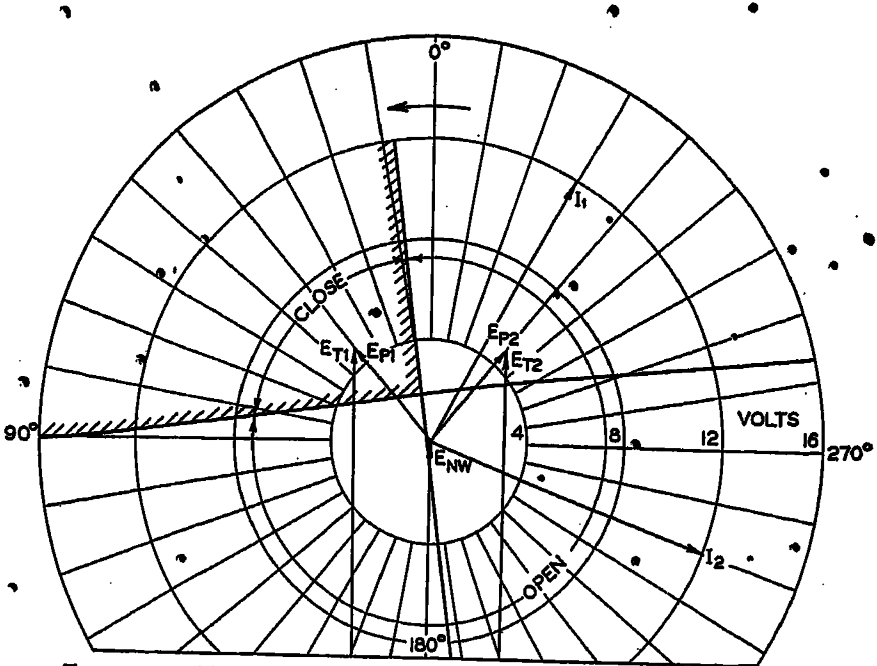


Fig. 4. Closing characteristics of master and phasing relays combined

bus sections of the same generating station, or perhaps from different generating stations, the phase angle between network and transformer voltages with a network protector open may be appreciable. If, during a light load period, the transformer voltage is greater in magnitude than the network voltage but lags it, the phasing voltage may, when the breaker closes, cause power to flow from the network to the feeder. The direction of power flow depends upon the phase angle of the phasing voltage and the impedance angle of the system through which it flows. When such a reversal of power flow occurs, the master relay alternately causes the circuit breaker to open and close, a condition commonly referred to as pumping. Two methods of preventing protectors from pumping are available: one is to add an additional relay called the phasing relay to keep the circuit breaker open when this voltage condition exists; the other is to alter the opening characteristic of the master relay so that it will open the breaker only when the reverse power exceeds a predetermined value. Both methods have been used, each having certain advantages and disadvantages.

The phasing relay is similar to the master relay except that it has a single element and no current coil. The contacts of this relay which controls only the closing of the circuit breaker are in series with the closing contacts of the master relay so that both must be in the closing position before the circuit breaker can close. The constants of the coils in the phasing relay are such that when the phasing voltage is 90 deg. out of phase with the network voltage, maximum torque is produced, the characteristic curve thus being approximately at right angle to the closing curve of the master relay. This relay has an adjustable voltage setting similar to that of the master relay and also an adjustment of the potential circuit constants which permits the curve to be rotated slightly.

## OPERATING CHARACTERISTICS OF PHASING RELAY

The closing curve of the phasing relay combined with that of the master relay is shown in Fig. 4. Only those phasing voltages which extend into the upper left-hand quadrant will cause the relays to close the circuit breaker. Thus, the circuit breaker cannot close when a phasing voltage such as $E_{P2}$ exists and which, with little or no load to be supplied, would cause current $I_2$ to flow and re-open the circuit breaker.

## OPERATING EXPERIENCE

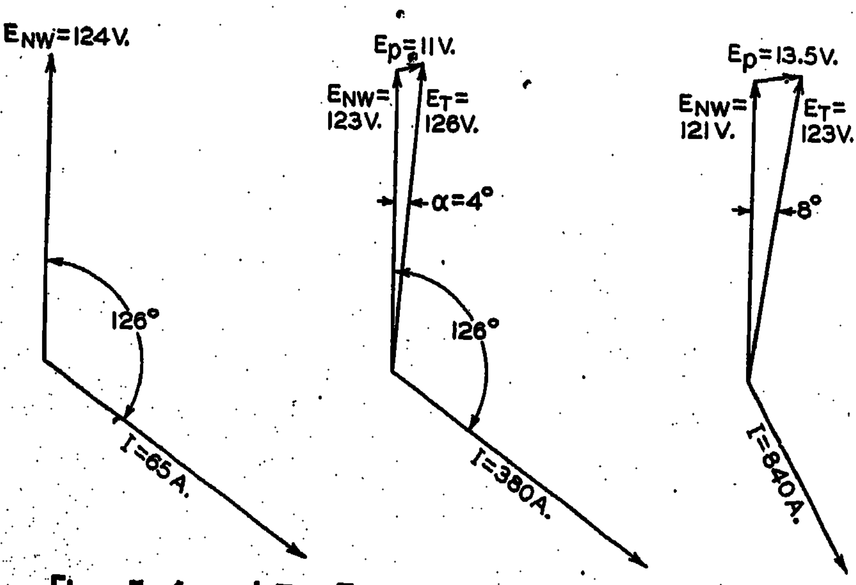
Experience has shown that when phasing relays are necessary to prevent pumping certain protectors may be open at all times except during peak load or may not close at all. When a network is small and the distribution transformers are widely spaced, open protectors are a cause of voltage complaints. If there is an intermittent load on the network occasioned by the starting current of a large motor or electric welding equipment, a voltage dip will occur each time the load comes on, because the transformer capacity is insufficient until the open protectors close. A more serious condition may result if a network is supplied by only two or three feeders, and leading voltage on one feeder keeps the protectors on the others open; for should the first feeder develop a fault, the network will be completely deenergized while the open protectors are closing. The duration of such an interruption of course would be very short; but still it would be sufficient to shut down synchronous machinery or any apparatus controlled by relays operating on loss of voltage. Furthermore, the number of protector operations would be increased. This is an objectionable feature from the standpoint of maintenance and public relations.

## PROVISION FOR NON-SENSITIVE RELAY SETTINGS

As a result of experience and investigation the protectors now being purchased by the New York and Queens Electric Light and Power Company have provision for altering the relay opening characteristic so that the relays may be given reverse current settings up to 20 per cent of the protector rating. The

Westinghouse company provides a spring restraint on their master relay which will give a reverse setting from 0 to 25 amperes. From 25 to 320 amperes the setting is obtained by means of the shunt reactor method. This method consists of connecting a reactor in parallel with each current coil of the relay so that less than 10 per cent of the current in the secondaries of the current transformers flows through the relay. Thus a relay set to trip on 25 amperes in-phase component of reverse current without the reactors, will trip on approximately 250 amperes with the reactors. An additional feature is a set of contacts in each reactor circuit which open on overcurrent of approximately 150 per cent of the protector rating; for example, when the current on a 1,600-ampere protector exceeds 2,000 amperes, these contacts open and the relay setting drops to that of the spring adjustment. The combination of shunt reactors and cut-outs makes the relay insensitive to all reversals of power obtained under normal conditions, but sensitive to feeder fault conditions.

The General Electric master relay also has a spring restraint which will provide settings between 0 and 25 amperes. To obtain settings above 25 amperes a voltage-restraining element is added. This element, which has two potential circuits, exerts a closing torque upon the bottom disk of the relay. The circuits are energized from the delta side of a $Y$-delta transformer. The torque exerted by this element is proportional to the area of the delta and as the area of the delta decreases rapidly for single-phase or phase-to-ground faults the restraint or setting decreases likewise. When unbalanced faults occur, one of the watt elements has to provide all or most of the opening torque, and unless the restraint is reduced in some fashion, abnormally high current is required to cause the relay to open the circuit breaker. To further assist the relay on unbalanced faults, the potential coils of the watt elements are connected phase-to-phase instead of phase-to-ground when voltage restraint is applied. The phase-to-phase voltages are sustained nearer their normal value and so are better able to produce an opening torque than are the phase-to-ground voltages.



**Figs. 5, 6, and 7. Test data of reverse power flow**

A back-feed condition caused by a 116-ton punch press driven by a 75-hp. induction motor is shown in Fig. 5 (left). The down stroke of the press drives the motor above synchronous speed and when there is little additional load in the plant, power is supplied to the feeder as indicated; this back-feed caused the protectors to open and the protector relay had to be given a setting of 150 amperes. In Fig. 6 (middle) is shown a back-feed condition due to a phase angle difference between two 4,000-volt feeders supplied by different generating stations. The relays at this location could not be set high enough to carry the back-feed current so a phasing relay was used to prevent pumping. An extreme case, shown in Fig. 7 (right) resulted when two transformers in the same vault were connected to 26.4-kv. feeders from different generating stations, the transformers being lightly loaded during the period of heavy feeder load. The use of a phasing relay to hold the protector open was the only solution

## LIMITATIONS

The objection to the use of non-sensitive settings is that protectors will not open when the station feeder breaker is opened or assuming the network transformers to be connected delta-$Y$, when a fault occurs between one conductor of the feeder and ground. If the feeder charging current is small or if it is so divided among the transformers connected to the feeder that the amount through each is small, the only disadvantage is the necessity of manually opening the closed protectors. However, if charging current of 3,000 amperes or more were permitted to flow through one transformer, the voltage of the network in the vicinity of the transformer might be raised to a value which would endanger utilization equipment.

The extent to which the network voltage might be raised would depend upon the impedance of the network as well as upon the magnitude and phase angle of the current. If the charging current of a 26.4-kv. feeder, 5 miles or more in length, were supplied by one transformer, the voltage probably would rise 20 per cent, and for certain values of current and impedance might rise 50 per cent. In order that such a condition shall not exist it is the practise in the Borough of Queens to reduce the charging current of each feeder to a safe value by connecting shunt reactors. The lagging current drawn by these reactors added to the charging current gives a resultant current of a magnitude and phase angle which will not cause an objectionable voltage rise.

Experience on this system has been that protectors on 26.4-kv. transformers can be operated with sensitive relays if care is taken in the choice of feeders supplying adjacent transformers. It is intended to limit each protector to one operation a day, and of course to keep all protectors closed which if open would cause the network voltage to drop below the allowable minimum. At the present time only one protector of a total of 150 associated with 26.4-kv. transformers requires a non-sensitive setting.

The use on 26.4-kv. feeders of shunt reactors and sensitive relay settings has resulted in correct relay operation both when feeders are opened at the stations and when phase-to-ground faults occur. However, on lower voltage feeders non-sensitive settings often are required making it necessary to open these protectors manually before a feeder can be cleared for construction work. This means considerable delay and additional expense which should be avoided if possible. This limitation of the present network protection and a desire to simplify the relays have caused considerable thought to be given to new protective schemes.

### FUSES

The network protector fuses which are of the link type and of either copper or alloy, provide back-up protection in case the protector fails to open the circuit in the normal manner when a fault occurs on the feeder side of the protector. They provide protection also to the network transformer when a fault occurs on the network side of the protector which because of its proximity to the transformer, its duration, or both, may result in the transformer becoming overloaded beyond its thermal capacity.

The minimum blowing value of these fuses is approximately three times the full load current of the transformers. This value is less than the value of short-circuit current which will flow into a fault on the transformer side of the protector from an extended network having ample transformer capacity; but this minimum blowing value may not be less than the value of short-circuit current if the transformers are few and widely spaced. However, to use a fuse of lower minimum blowing value would result in unnecessary blowing of fuses with network faults.

Although the blowing of fuses due to network faults has been very infrequent, a solid fault near a transformer which does not clear immediately will cause the fuses to blow. In an area of high load density with transformers a block apart a fault on the network may cause the fuses in three protectors to blow. The disconnecting of this amount of transformer capacity from the network in one locality would result in low voltage.

The use of plain link fuses for back-up protection has certain disadvantages. If the minimum blowing value is low enough to insure opening the circuit for lower values of short-circuit current flowing toward the transformer, they will blow so rapidly on the high values that this blowing may take place before the protector circuit breaker can open. To protect the transformer against overheating when supplying current to network faults, the fuses should have a current-time curve similar to but slightly below the maximum safe current-time curve of the transformer. Because of the pronounced difference in their thermal capacities the curve of the fuse has a steep slope whereas the curve of the transformer has a gradual slope. Thus a fuse which will blow at low values of current only when the transformer has reached its maximum safe temperature, will blow too soon at higher values, and probably unnecessarily. A third disadvantage is the amount of heat generated by the fuses. Elimination of this heat in protectors enclosed in submersible boxes should permit an increase in their current rating.

In place of link fuses there is need for a back-up circuit breaker of small dimensions and low cost which can be given a definite time, overcurrent setting for current flowing from the network, and an inverse time, overcurrent setting for current flowing toward the network. The inverse current-time curve should parallel closely the maximum safe overcurrent-time curve of a distribution transformer.

# Molybdenum—

## *The Metal That Talks*

DISCOVERED BY SCHEELE in 1778 in the form of an oxid, molybdenum was first separated as a metal by Hjelm in 1782. Now it is produced commercially by hydrogen reduction of the oxid, pure oxid being obtained from ammonium molybdate. The resulting metallic powder is sintered, forged, and rolled into desired shapes. When pure, molybdenum is soft, white, and ductile.

During the last 35 years a great deal of research work was done in Europe, Japan, and the United States; many characteristics of the metal were developed. It did not come into prominence, however, until the World War when it was used extensively as an alloying element in light armor plate, helmets, and Liberty engines, because of the great increase in strength and toughness imparted by it to steel.

Even in war time, however, its application was limited, due to uncertainty of supply and high cost. In the last few years large deposits of ore have been discovered in the United States; there are deposits of varying richness in many parts of the world, but the largest and richest known are in this country. Commercial deposits are found ranging in richness from 0.5 per cent up to 8 or 10 per cent molybdenum sulphide ($MoS_2$). After grinding and flotation, the ore is concentrated to about 80 per cent $MoS_2$; from these concentrates commercial products are made. Rapid lowering of cost by increased production has resulted in a large portion of the world's requirements being supplied from American mines. Hence in times of stress this important element could not be shut off from this country as could some alloying elements used in steel.

It has been said that, excepting carbon, molybdenum is the most potent alloying element added to steel. It can be substituted for tungsten in ratio of 1 for 2. In quantities generally used in steel, molybdenum for the most part goes into solution with the iron, although it forms a double carbid when present in amounts of more than 1 per cent or when considerable quantities of chrome or manganese are present. It also is probable that when cooled through the critical range, a definite compound of molybdenum and iron is formed. Used in amounts as small as 0.1 per cent or 2 lb. to the ton, it has shown marked tendencies in resisting corrosion. In quantities up to 10 per cent it offers a possible substitute for tungsten high speed tool steels.

Thin-walled, high-strength, chromium-molybdenum steel tubing has made modern high speed airplanes possible, and no substitute has been found for highly stressed members in the fuselage. Such tubing combines the unusual advantages of high

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strength without complex heat treatment, easy weldability, and no appreciable loss of desirable properties in welded joints; it enables designers to increase strength with no increase in weight.

The pure metal is used extensively in the incandescent and radio bulb industry. According to a booklet, "Rare Metals" (Fansteel Products Company, North Chicago, Illinois): "To say that the air or ether carries the radio broadcast wave is true, but it's a certain metal sealed tightly in tubes which puts the wave on the air, and, then in different tubes, recaptures it to be turned back into music or words. This metal is molybdenum—the metal that talks." Literally thousands of miles of molybdenum wire, drawn through diamond dies, have been used in the radio industry.

But that is not all, for, in the form of salts and oxids, this versatile metal is used in the chemical and dye industries. Thus do we find modern industry, engineering, and research making a place for a material known for a century and a half, but little used until within the last few years.

# Engineering Features of Gas Filled Tubes

**Introduction of gas or vapor into electron tubes has increased greatly the field of application of these devices. Hot-cathode mercury vapor tubes of this type are especially adapted to rectifier and inverter service. Fundamentals, design features, and operating characteristics of these tubes are given in this article.**

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DURING the past few years vacuum tubes have found an ever enlarging field in industrial applications. This has been brought about primarily by vast improvements in the design of the tubes themselves. In addition, the more recent gas filled tube provides the application engineer with a tool even more suited to his needs. Some of the outstanding engineering features of gas filled electron tubes are as follows:

1. The tubes are static devices[1] (For numbered references see bibliography.), the complete functions of which are performed through the movement of electrons and ions.

2. Efficiency in controlling or converting power is high; tube efficiency ranges from 95 to over 99 per cent.

ıtrol is flexible and the power required for control is small.

4. Speed of operation as a relay is extremely fast, and in addition the tube may function either cycle by cycle or intermittently without the wear that accompanies the operation of mechanical devices.

5. Noise and vibration are entirely absent.

The name "Phanotron" has been applied by the General Electric Company to gas or vapor filled electron tubes, and in that company's practise the name has become associated with the two-element or simple rectifying tube. Tubes of this type in which the starting of the conduction period is controlled electrostatically by the action of one or more grids, have been termed "Thyratron" tubes, the name being coined from the Greek "thyra-," meaning "a door," and "-tron," meaning "a device."

## FUNDAMENTALS OF THEORY AND OPERATION

Theory and operation of vacuum and gas filled tubes have been treated previously.[2,3,4] Briefly, the theory in the case of a high-vacuum tube is that electrons can be drawn from the cathode to the anode when the potential of the anode is above that of the cathode. These electrons in passing from cathode to anode form a charged cloud which gives the so-called space-charge voltage drop that depends upon electrode spacing, current drawn, and several other factors; it may vary in magnitude from a few volts to several thousand. In the gas filled tube, electrons are drawn from the cathode as before, but collide with gas molecules in passing to the anode thereby causing ionization which neutralizes the space-charge. Color and appearance of the glow produced is characteristic of the gas and its pressure. The magnitude of the arc drop voltage is practically independent of the current drawn, and for thermionic cathodes within the limits of the tube design is of the order of from 5 to 25 volts. The voltage drop depends upon the available cathode emission, nature and pressure of the gas, and the design and spacing of the tube elements. When the potential of the anode becomes negative with respect to that of the cathode, conduction ceases.

Simple gas filled rectifier tubes consist essentially of two elements: an anode and a cathode, surrounded by an evacuated container into which a partial atmosphere of an inert gas or vapor has been introduced. The cathode may be of the cold, thermionic (hot) or mercury pool type. Any of the

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y full text of "Engineering Features of Phanotron Tubes" presented ..E.E. North Eastern District meeting, Providence, R. I., May 4–7, *i published in pamphlet form.*

inert gases, such as argon, neon, or helium, mercury vapor, or a combination of these elements may be used. In the more common tubes, the cathode is of the thermionic type, and the vapor pressure is supplied by a small quantity of mercury. During operation nearly all of the current is carried by electrons from the cathode while the positive ions serve mainly to neutralize the space-charge voltage drop.

In the three-element tube a control grid has been added which interposes an electrostatic screen between the anode and cathode as in the high-vacuum tube. When a direct potential is applied to the anode of a high-vacuum tube, its grid gives a continuous, uniform control of the anode current. In the gas filled tube the grid as usually operated controls only the starting of the current and thereafter exerts no appreciable influence upon the current flow. Grid control can be reestablished, however, by removing, reducing to zero, or reversing the polarity of the anode voltage for a period sufficiently long to allow the tube to deionize. If an alternating potential is applied to the anode, the grid has opportunity to regain control during the negative portion of each cycle and to delay the starting of the anode current for as long a period in the positive portion of the subsequent cycle or cycles as desired. It is possible thus to control the average current flowing through the tube.

Control of the average anode current may be obtained by several methods. The critical grid voltage at which conduction takes place when an alternating potential is applied to the anode is somewhat in the form of a sinusoidal wave in phase opposition to the anode voltage. (See Fig. 1.) When a direct potential is used for grid control, the average output varies from zero to half voltage in one step and is then uniform from half to full voltage. If, however, the grid as well as the anode is supplied with an alternating potential of the same frequency, and further, if the phase relations between the grid and anode voltages can be varied, complete and uniform control of the average voltage output may be obtained. In Fig. 1 is shown the effect on the output (shaded portion) as the grid potential is successively advanced from the nearly out-of-phase position (*A*) to the in-phase position (*C*). The output may be controlled also by varying the magnitude of the grid potential and by combinations of the d-c. bias, phase, and magnitude methods.

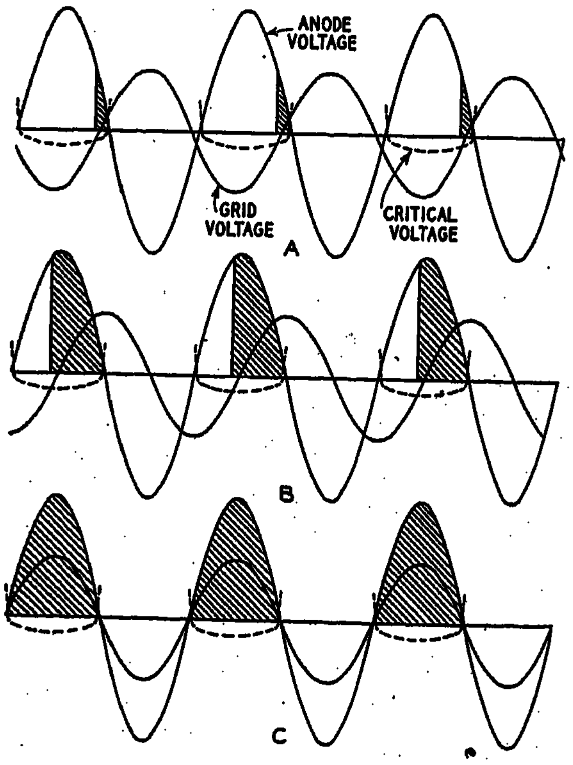


**Fig. 1. Control of average output voltage of a gas filled rectifier tube by grid phase-shift method; shaded parts indicate relative average outputs for the three conditions**

A—Anode and grid voltages nearly out of phase; B—displaced about 90 deg.; C—in phase

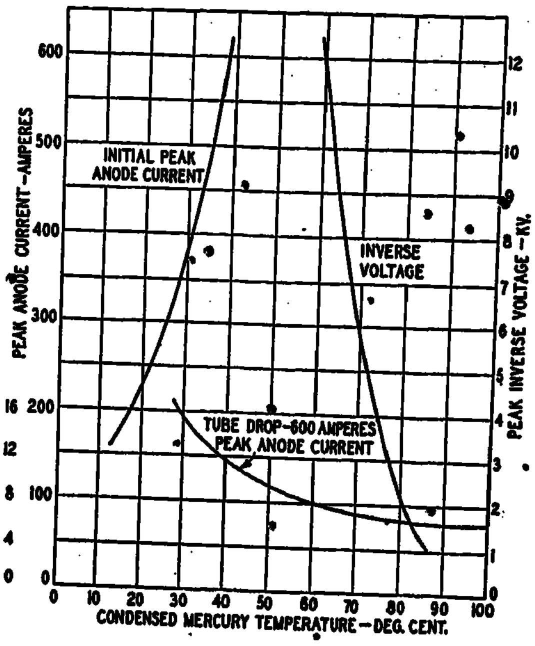


**Fig. 2. Tube voltage drop, arc-drop potential, and initial anode current at start of conduction, for a typical two-element mercury-vapor tube**

## TUBE DESIGN AND OPERATING CHARACTERISTICS

Certain factors of tube design warrant special attention. The type and form of the cathode and anode, the operating pressure of the gas or vapor and the type of grid control require a close degree of coordination in order to insure satisfactory performance.

*Cathodes.* As already mentioned, three general types of cathodes are in use, namely: the cold, the mercury pool, and the hot or thermionic types. In the cold cathode, electrons are drawn from the cold surface of an electrode through the action of an intense electrostatic field. Cold cathode tubes have a relatively high voltage drop and a comparatively small current carrying capacity.

In the mercury pool tube a cathode spot is established and maintained on the surface of the mercury by auxiliary electrodes. The pool cathode is well known through its use in mercury arc rectifiers[5] and has ability to supply high peak currents. An adequate cooling surface must be provided to condense the mercury evaporated by the cathode spot. Since the tube elements must be shielded from the blast of evaporating mercury and spray, the arc drop voltage usually is higher than that of tubes with equivalent thermionic cathodes.

Hot or thermionic cathodes furnish electrons through the heating of a metal that is an active thermionic emitter or that has been coated with an electron emitting material. The hot cathode used in the majority of gas filled tubes is of the Wehnelt or oxide coated form because of its efficiency, durability, and reliability of operation.

Oxide coated cathodes may be divided into two general types: (1) the filament or directly heated type, and (2) the indirectly heated type. Filament cathodes are used in some of the tubes where rapid heating is essential, and may be shielded. In indirectly heated cathodes, the heating element is

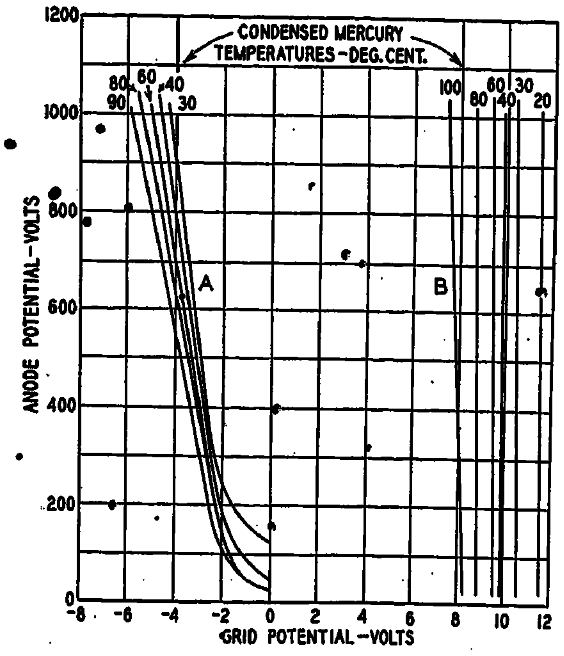


**Fig. 3.** Voltages at which conduction starts for two typical three-element mercury-vapor tubes with (A) negative control and (B) positive control

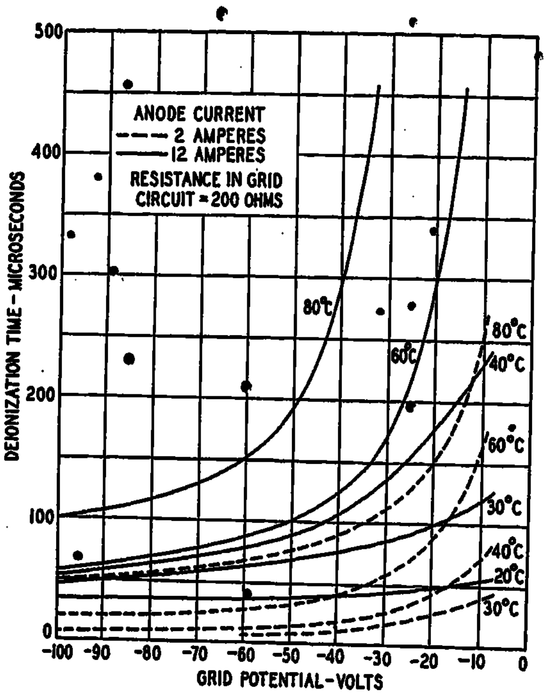


**Fig. 4.** Deionization time at different condensed mercury temperatures of a three-element mercury-vapor tube designed primarily for inverter purposes

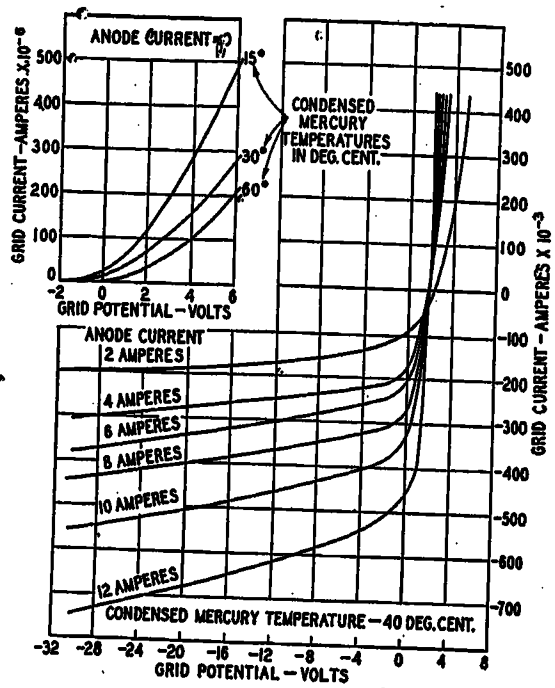


**Fig. 5.** Grid current vs. grid voltage for several values of anode current for same tube as in Fig. 4

commonly a separate tungsten heater which through radiation or conduction, supplies its energy to the emitting surface.

Heat shielding and concentration of the cathode in small space are made possible in gas filled tubes through ionization of the gas which neutralizes any space-charge and permits electrons to be drawn from crevices and made to emerge from comparatively small holes in the cathode shields. This would be impracticable in high-vacuum tubes. Time required for a cathode to reach operating temperature is a function of the ratio of cathode mass to heating power; consequently, the heating time is a minimum in unshielded cathodes and increases with shielding. In general, the more efficient the cathode, the longer is the heating time. Potential at which the cathode heating power is supplied is held below the ionization potential of the gas (10.4 volts for mercury vapor).

*Gas Pressure.* Pressure of the gas governs the temperature limits of operation in any gas filled tube. In mercury vapor tubes, the pressure is determined by the temperature of the coldest part of the tube; mercury condenses at this point and a measurement of the temperature gives an indication of the pressure in the tube. With excessive gas pressure, conduction in the reverse direction or arc-back may occur; also under these conditions a three-element tube may lose control. If the pressure is too low, the arc voltage rises above the critical value[2] at which cathode disintegration begins. In addition, low vapor pressure seriously reduces the ability of the tube to start conducting heavy currents; under such conditions, sputtering of the cathode and sometimes arc-back may occur. In general there exists a definite range of pressure for satisfactory operation. For most tubes this range of pressure corresponds to ambient air temperature of from 20 to 50 deg. cent. Temperature rise of the condensing mercury above ambient varies from approximately 15 to 50 deg. cent., depending upon the tube design. These conditions are illustrated in Fig. 2.

Control characteristics of tubes in which an inert fixed gas is used are nearly independent of ambient temperature changes. This characteristic is of particular advantage where large ambient temperature variations are encountered and where constancy of control is desired. Pressure limits are determined by loss of control and reverse current conduction for the upper limit, and by gas "clean-up" for the lower. However, the operating ranges of voltage and current are far less than those of similar mercury vapor tubes.

*Control Characteristics.* Two classifications of three-element tubes are made with regard to the control characteristics—negative and positive. A negative control tube is one the critical grid voltage of which is negative with respect to the cathode over most of the operating range. Since conduction starts when the grid is negative, very little grid current is drawn before discharge. A positive control tube is one in which the critical grid voltage is positive over most of the operating range. In this type the electrostatic field of the anode is relatively weak at the cathode; consequently, it is necessary to drive the grid positive in order to establish conduction. It may even be necessary first to produce ionization between cathode and grid before anode conduction occurs. Control curves for the two types are shown in Fig. 3.

*Ionization and Deionization Time.* The time required to establish conduction, sometimes called "ionization time," varies from less than 1 microsec. in two-element tubes and some of the negative control three-element tubes to several microseconds in the positive tubes; it varies with the vapor pressure, tube design, and grid excitation.

Time required to regain control, or the "deionization time," varies with the anode current, vapor pressure, grid excitation, and anode voltage change.[4] Length of the deionization time may vary according to tube design from a few microseconds to approximately 1,000 microsec. This factor is of little importance in ordinary rectifiers or in controlled rectifiers utilizing three-element tubes when operating at the usual distribution frequencies. Commutation or current transfer from one tube to another is natural and sufficient time exists to regain grid control. In inverters, however, commutation is forced and the available time to regain grid control is short; consequently, tubes having high speed deionization qualities are essential. Deionization time for one type of three-element tube is given in Fig. 4.

Grid current before and after ionization occurs is shown in Fig. 5. These curves illustrate the need of carefully designed grid circuits in order that the grid currents which flow when the gas is ionized do not unbalance the control circuit.

### RATINGS OF GAS FILLED TUBES

Certain ratings used in describing gas filled tubes are peculiar to these tubes; some of the more important of these are:

1. Maximum peak inverse voltage.

This is a rating applying to both two- and three-element tubes; it represents the maximum voltage that should be applied between anode and cathode of a tube during operation when the anode is negative with respect to the cathode. Under normal conditions this voltage is simply the crest of the total transformer voltage. These theoretical values may be exceeded several fold under abnormal conditions due to line surges or other disturbances. Determination of the actual peak inverse voltage is necessary in such cases; this may be done conveniently by means of a sphere gap or cathode ray oscillograph. Theoretical peak inverse voltages for several commonly used rectifier circuits are shown in Fig. 6.

2. Maximum peak forward voltage.

This rating applies to three-element tubes only; it represents the maximum positive anode potential that the grid will control when supplied with suitable voltage. In general, the magnitude is the same as that of the maximum peak inverse voltage.

3. Maximum peak anode current.

This is an indication of the available cathode emission, and, for a given life and service, represents the highest instantaneous current a tube will conduct in the normal direction of current flow. The length of time a tube will withstand a given instantaneous current or the frequency with which it will withstand an instantaneous current of given duration depends upon the ability of the tube to dissipate heat.

4. Maximum average anode current.

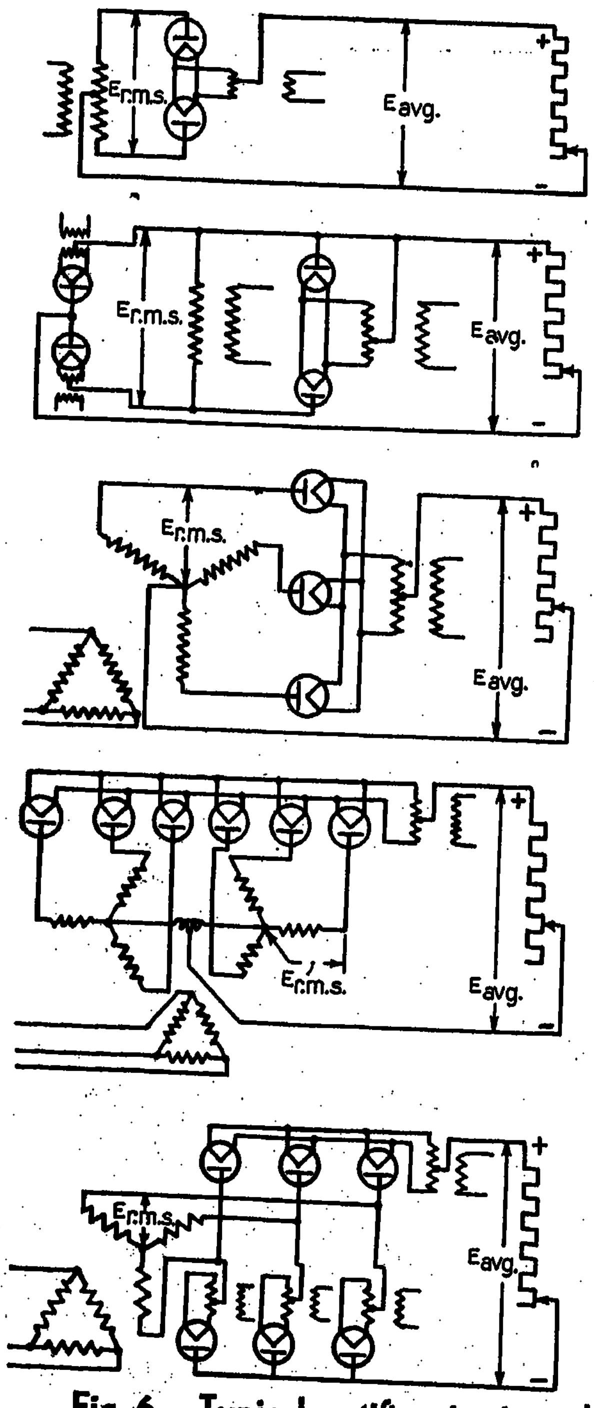
This is a rating based upon tube heating and represents the highest average current that can be carried continuously. Equilibrium temperature of the tube elements is reached quickly for a given load because the elements in general have a small mass; consequently, in addition to the average current rating the integration period must be stated. Losses in the arc vary directly with the average current rather than the value, since the arc drop is practically constant and independent of the current.

5. Maximum surge current.

Under abnormal operating conditions, such as occur when a rectifier is short-circuited, the anode current becomes limited almost entirely by the transformer and line impedance. The short-circuit impedance of power transformers usually is of the order of from 5 to 10 per cent of the rated impedance; consequently, the short-circuit current may reach values of from ten to twenty times normal. In order to indicate the available transient emission of the cathode a "maximum surge current" rating sometimes is given. Individual tubes may fail under short-circuit conditions, but experience indicates that with proper circuit and tube coordination, the majority will stand a great deal of punishment.

6. Maximum peak and maximum average grid currents.

These represent the grid current ratings; usually they have the same integration period as that of the anode current rating.



Bi-phase half-wave, 2 anodes
$E_{avg.} = 0.318\ E_{max.}$
$= 0.450\ E_{r.m.s.}$
$E_{inverse} = 3.14\ E_{avg.}$

Bi-phase full-wave, 4 anodes
$E_{avg.} = 0.636\ E_{max.}$
$= 0.900\ E_{r.m.s.}$
$E_{inverse} = 1.57\ E_{avg.}$

Three-phase half-wave, 3 anodes
$E_{avg.} = 0.827\ E_{max.}$
$= 1.170 E_{r.m.s.}$
$E_{inverse} = 2.09\ E_{avg.}$

Double-Y three-phase half-wave, 6 anodes
$E_{avg.} = 0.827\ E_{max.}$
$= 1.170\ E_{r.m.s.}$
$E_{inverse} = 2.09\ E_{avg.}$

Three-phase full-wave, 6 anodes
$E_{avg.} = 1.65\ E_{max.}$
$= 2.34\ E_{r.m.s.}$
$E_{inverse} = 1.047\ E_{avg.}$

**Fig. 6. Typical rectifier circuits and voltage relations for two-element tubes**

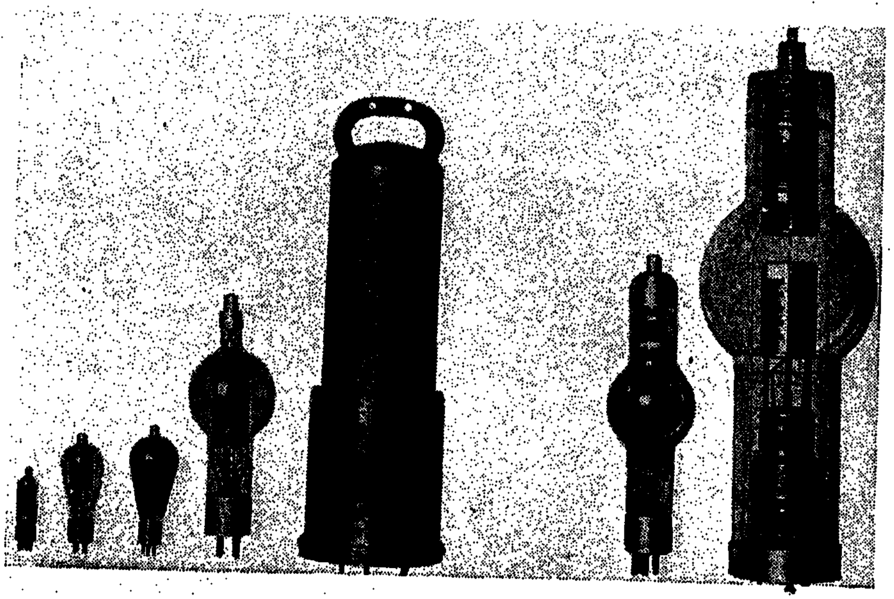


**Fig. 7. A group of three-element vapor-filled tubes for control, power rectifier, and inverter purposes**

The group of five tubes on the left have maximum peak anode current ratings of from 0.5 ampere for the smallest to 600 amperes for the large metal-clad tube, peak forward and inverse voltage ratings range from 1,000 to 3,500 volts. The two tubes on the right have peak ratings of 15,000 volts and are capable of conducting peak anode currents of 75 and 450 amperes, respectively. Two-element tubes of similar dimensions and ratings also have been developed

Fundamentally, the application of these tubes may be divided into two classes: (1) that of the rectifier in converting alternating current into direct current with or without voltage control; and (2) that of the inverter[6] in changing direct current into alternating current.

## RECTIFIER APPLICATION

A typical circuit for a bi-phase, half-wave rectifier with voltage control is shown in Fig. 8. (The term "bi-phase" is a part of a proposed circuit nomenclature for rectifiers.) Current and voltage relations in this circuit are shown in Figs. 9, 10, and 11, for loads approximating resistance, inductance and capacitance operation, respectively. In each case the oscillograph elements have traced the output and anode voltages, and the anode current of one tube.

Oscillogram *A* of Fig. 9 shows voltage and current relations for the rectifier with a resistance load and operating at full output; that is, the grid voltage is in phase with the anode voltage. In oscillogram *B* the grid voltage has been retarded approximately 90 deg. so that anode conduction begins at about the peak of the anode voltage wave. The sudden doubling of the inverse voltage is due to the start of conduction in the opposite tube. With no current flow in either tube, the cathodes assume the potential of the transformer mid point; consequently, the inverse voltage is only half of the transformer voltage. When conduction is established through one tube, the total transformer voltage (less the tube voltage drop) appears across the other.

Effect of introducing an inductance as a filter in the output circuit of the rectifier of Fig. 8 is shown in Fig. 10. In oscillogram *A* the grid voltage is in phase with the anode voltage and the relations correspond to those of simple two-element rectifier tubes. Oscillogram *B* shows the effect of retarding the grid voltage. In the case of a bi-phase rectifier operating with an inductive load, it is possible theoretically to control completely the voltage output with a total grid phase shift of 90 deg. An inductance is essentially a constant current device which stores or releases energy as the voltage applied to it rises or falls. Consequently if the anodes are made conducting by the grids at the peaks of the applied voltage waves or later, anode current will flow in each tube until transferred to the other, or for 180 deg. During half of this time, however, the anode voltage will have reversed its polarity and the net output is zero. The energy relations correspond to those of a circuit with a 90 deg. lagging power factor. The effect of leakage reactance in the transformer upon the commutation or transfer of current from one tube to the other also is shown.

Commutation in a rectifier is a natural process, since the anode voltage of the tube that is ceasing to conduct is falling and that of the incoming tube is rising. During the period when both tubes are conducting, a short-circuit current begins to flow in the reverse direction through the tube that is ceasing to conduct. When the peak of the short-circuit current reaches the value of the previous anode current, conduction ceases.[5]

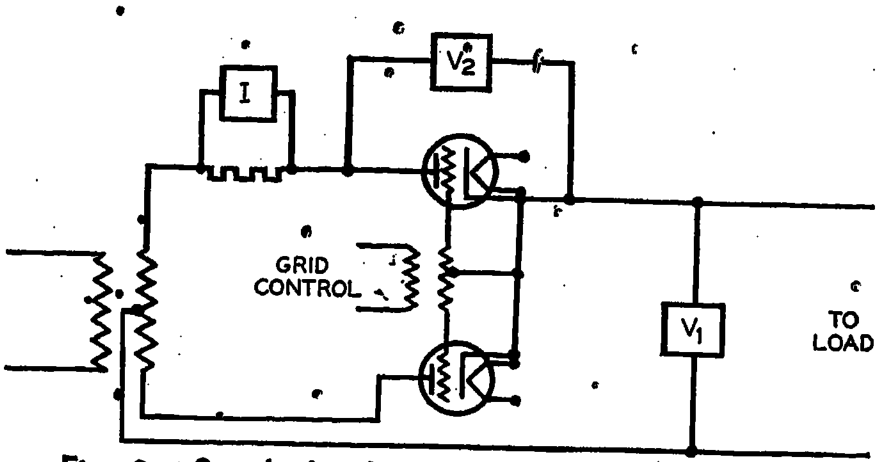


Fig. 8. Simple bi-phase half-wave rectifier circuit using three-element tubes; I, V₁ and V₂ indicate connection of oscillograph elements for determining voltage and current relations shown in Figs. 9, 10, and 11

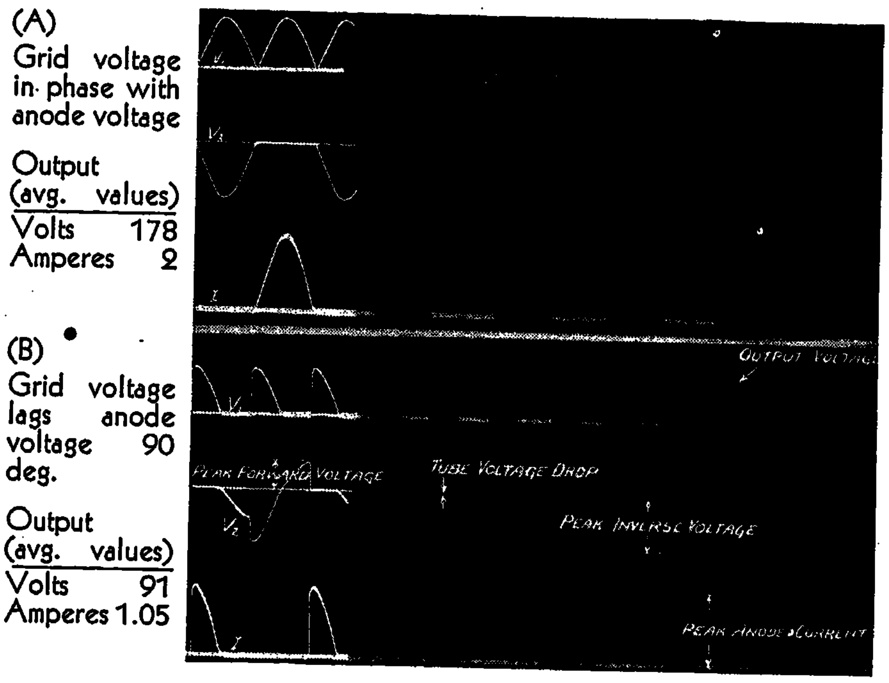


Fig. 9. Voltage and current relations for rectifier of Fig. 8 with resistance load

Portions of the curves have been strengthened for clarity

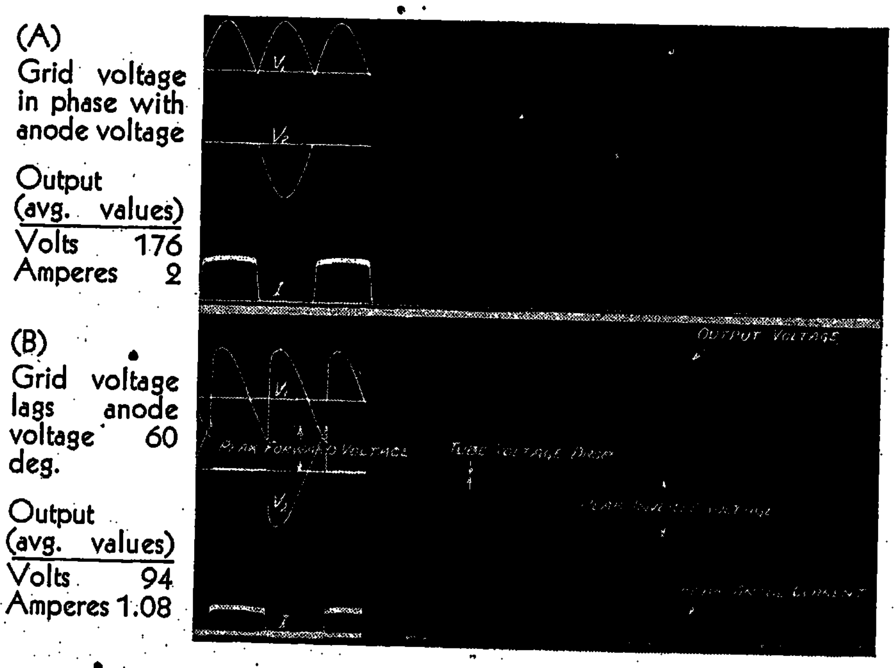
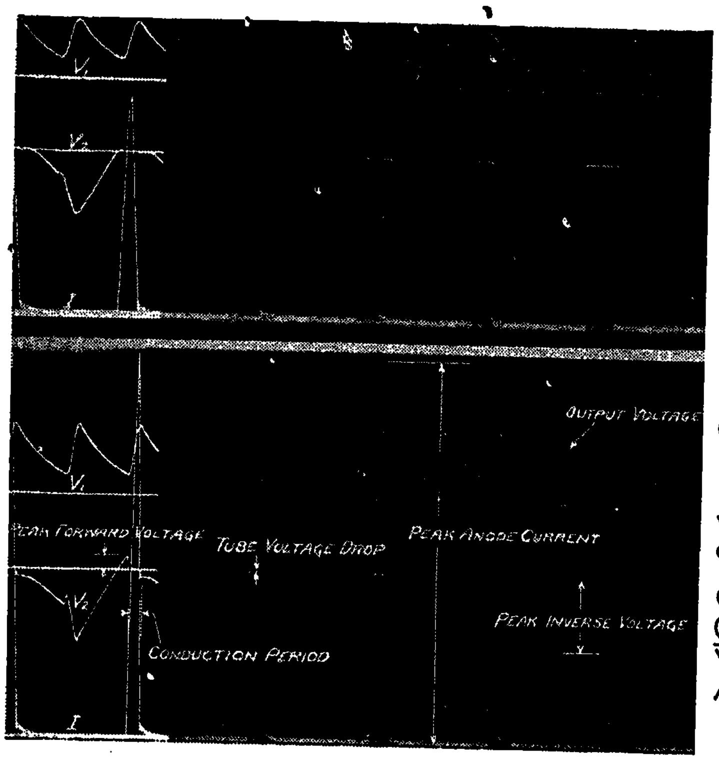


Fig. 10. Voltage and current relations for rectifier of Fig. 8 with series resistance and inductance load

Portions of the curves have been strengthened for clarity

In Fig. 11 operation of the rectifier of Fig. 8 with shunt capacitance is shown for two phase positions of the grid voltage. The peak anode currents that are drawn illustrate quite clearly the low internal



(A)
Grid voltage in phase with anode voltage

Output (avg. values)

| | |
|---|---|
| Volts | 220 |
| Amperes | 1.8 |

(B)
Grid voltage lags anode voltage 70 deg.

Output (avg. values)

| | |
|---|---|
| Volts | 240 |
| Amperes | 2 |

**Fig. 11. Voltage and current relations for rectifier of Fig. 8 with resistance load shunted by capacity**

Portions of the curves have been strengthened for clarity

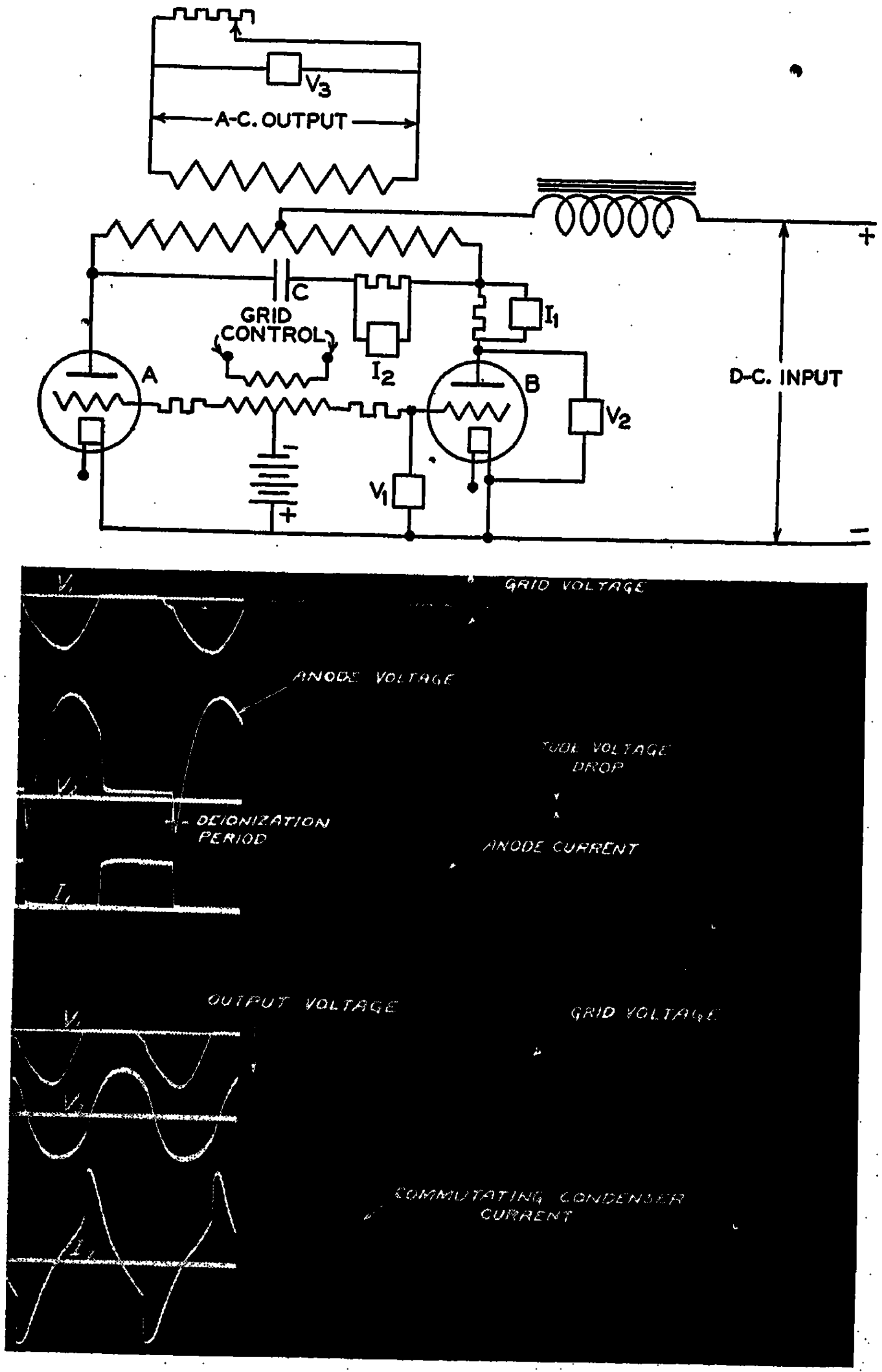


**Fig. 12. Single-phase inverter circuit for changing direct to alternating current using three-element tubes, with oscillograms for various voltages and currents**

Portions of the curves have been strengthened for clarity

resistance of gas filled tubes. With capacitance operation the maximum peak anode current may be unintentionally exceeded while operating at less than the average current rating.

## INVERTER APPLICATION

When applied to inverter operation the function of the three-element tube is essentially that of a switch for changing the unidirectional flow of direct current to alternate sections of transformer windings. In inverters some form of energy storage is necessary not only to commutate the flow of current from one winding to another, but also to aid in deionizing the tube and so establish grid control.

A simple single-phase inverter circuit is shown in Fig. 12. In operation the grid of tube *A*, for example, is made sufficiently positive to establish conduction, while the grid of tube *B* is held sufficiently negative to maintain control. Current then flows from the d-c. source through the inductance and one half of the transformer winding, completing the circuit through tube *A*. Commutating condenser *C* becomes charged negatively at tube *B* and positively at tube *A*, to a potential the value of which is nearly twice that of the d-c. line. At the end of the cycle the polarity of the grids is reversed and tube *B* is made conducting. Current that previously had been flowing through tube *A* is diverted to the condenser, and as conduction ceases the anode of tube *A* is driven negative, the grid thereby gaining control. Meanwhile, current flow is transferred to tube *B* and its half of the transformer winding; commutation of the tube currents is then complete. The condenser is charged again but with opposite polarity for repeating the switching operations. On the output side of the transformer the tube voltage waves combine to produce an alternating voltage that by proper circuit constants can be made practically sinusoidal.

Oscillograms of Fig. 12 were taken with the inverter operating at 60 cycles and supplying a resistance load. The relation of the condenser current to the anode current during the commutating period is shown clearly. During the commutation period in order that the grid may gain control, all ions within the tubes in the space between anode and grid must diffuse to the elements before the anode voltage becomes positive. The length of this period is extremely short in comparison to that available in a controlled rectifier. Consequently, the deionization time of the tubes for this service must be short, and in addition, both grid and anode must be designed to withstand severe ion bombardment.

In the present state of development the gas or vapor filled tube has increased manyfold the current carrying capacity of the electron tube. As the field of usefulness increases, even larger tubes and tubes with greater sensitivity of control may well be developed.

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# Labor and Engineering Progress

**Application of engineering methods, training, and skill to the social, political, and industrial problems of the present day would contribute in a valuable way toward satisfactory stabilization. This is the tenth article in The Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"**

By
WILLIAM GREEN

President, American Federation of Labor

TO SCIENTIFIC RESEARCH and to the engineers of this country we owe our notable progress in the technical side of industry. Mechanical power is replacing physical power. Workers are controlling machine tools that produce at a rate that would have staggered the giants of the legendary ages. Giant cranes, tractors, steam shovels, double crank presses, conveyers, cash registers, calculating machines, dynamos, and many other devices revolutionized industrial processes. Engineers are largely responsible for marvelous machine tools and for continued experimentation in chemical processes—to put to the service of mankind the last word in science.

The past ten years have brought unusual rapidity in technical progress. This is apparent from comparing the increase in productivity between 1919 and 1929 with that from 1899 to 1919: 54 as against 26 per cent. To state this in another way, this increase in productivity shows up sharply when translated into hours. Work that kept a workman busy 59 hours a week in 1899 was done in 47 hours in 1919; work which was done in a 52 hour week in 1919 was done in 34 hours in 1929. These increases in workers' productivity have brought a steady decrease in the unit costs of production.

In addition to improved tools and processes, the principles of mass production have made available to millions many products which formerly were luxuries within the reach only of those within the higher income brackets. The wage earner with an automobile has access to wider opportunities for work and choice in adjusting the details of living than the wage earner limited by his own traveling capacity. Life and work are now conditioned by control of horsepower. The radio brings him control over wider areas of information and contacts with the personalities and lives of others. Facilities for sanitation and cleanliness give wage earners of today comforts that not even royalty enjoyed two centuries ago.

On the employment side of the ledger, technical progress has brought exceedingly difficult problems to workers and industry. Our term *technological unemployment* expresses an experience that often has made science seem the enemy of wage earners. But this is because science has been used without taking into consideration the fact that wage earners have an equity in their jobs. How to make quantities has been learned, but not how to get them to the people who can use them, or how to distribute equitably the returns from joint products. Present attempts direct these modern currents through the old channels developed in the days of hand production.

Wage earners make a very important investment in industry. They put in the time and labor necessary to turn out the products of the industry; they put in their creative capacity, their intelligence, their work lives. The time has been reached when securities for these non-material investments must be given consideration commensurate with that for capital investments. Merely speeding up the industrial machine is not an unmixed good unless engineers realize that these changes profoundly affect human lives, and plan to make the influence constructive.

When undertakings are going to affect one or more groups, the only way to make sure that all those having legitimate interests are safeguarded is to provide for collective consideration and counsel. This is in accord with the engineering practise of finding and applying facts. This field of facts of human progress affords the ultimate tests of the value of engineering progress. Failure to consider the consequences of policies and changes upon interrelated interests results in perplexing problems that impede progress and precipitate strife.

World-wide economic distress has resulted from failure to recognize interdependence of national interest. Within our country is found failure to balance interests and progress. Custom has established certain priorities for material interests that have worked for unequal distribution of wealth and income and absence of security for many. Wage earners belong to the groups denied priorities in security.

It has been pointed out that, because all interests are interrelated, we must work out principles of balance; increasing output against capacity to buy; increasing productivity against increasing leisure, technical progress against the available supply of labor, output against the incomes of buyers, volume of business against available credit, etc. Sustained business prosperity can be attained only through an understanding and application of the principles of balance. The welfare of mankind can be advanced safely in this complicated age only when the principles of balance between forces which work for progress and retrogression are understood.

To define its status and well-being, Labor has outlined the following Labor program:

1. Organization of all functional groups to advance their group interests, and collective conferences and agreements to promote progress for all, in which Labor shall participate.
2. Reduction of weekly work hours as productivity increases.
3. Wage increases to raise consumer credit as output increases.
4. Partnership of labor in the production undertaking, carrying job, and income security.

Application of these principles would give Labor and all other groups a fair chance to advance their interests in individual establishments, but this is not enough. The industries of a nation are dependent upon each group for prosperity or depression. Therefore, there must be nation-wide planning by industries and collective discussion and agreement for the nation, together with consideration of the world market.

To these larger problems which include the intangible as well as the technical forces with which engineers are familiar, the engineers of the country can make valuable contributions. It is hoped that engineers will feel a responsibility for carrying their methods of work into the larger field.

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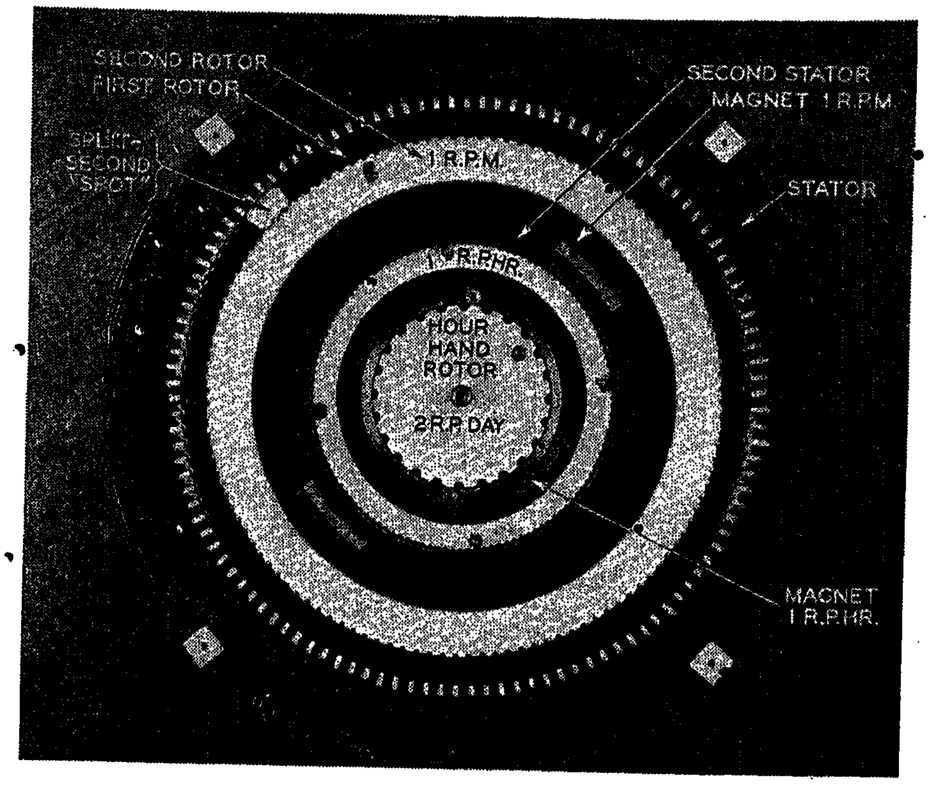
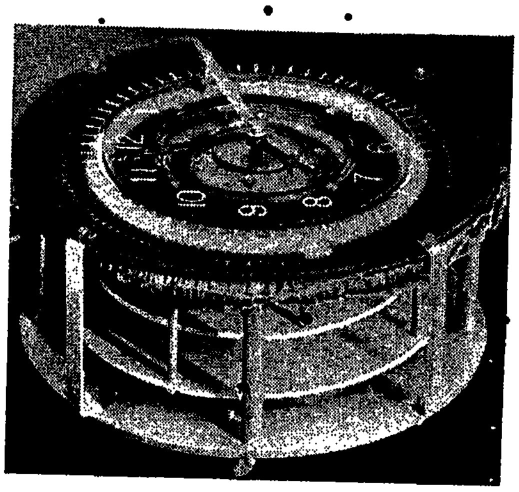
**Editor's Note:** Pursuant to the invitation of the Engineering Foundation, the editors will be happy to receive comments, criticisms, or discussions pertaining to this or other articles published in this series.

# Slow Motion Motor Will Run Indefinitely

WHILE one group of scientists has been perfecting electrical machinery that will run at higher and still higher speeds, another group has been going to the other extreme by perfecting a timing motor that will revolve only twice a day. By following the same principles the speed could be slowed down to one revolution per year or even less.





**Slow motion synchronous motor (above) as built for the experimental clock shown in the smaller view. There are only four moving parts, one for each hand and one for the split-second "spot." The clock is 10 in. in diameter and 6 in. high**

Theoretically there is no limit to the slowness that could be achieved, according to L. W. Chubb and T. R. Watts research engineers of the Westinghouse Electric and Manufacturing Company.

While the idea is still in the experimental stages and is not commercially available, the fact that it is practical and workable has been demonstrated in a clock of unique design. One feature of the clock is that it has only four moving parts, each of which is necessary to operate one of the hands. The fastest of these revolves only 60 times per minute. If the four points of wear were to be sealed in oil cups and jewels used for bearings as in good watches, the clock should run indefinitely without attention; of course such performance would require that the electric current never be interrupted.

In the accompanying illustrations are shown a view of an experimental model of the clock, together with a plan view of the slow motion motor. Just below the outer rim of the clock face is the stator of the motor having 118 iron teeth around its inside edge and wound so as to provide a revolving magnetic field. Inside this ring is the rotor around the outer edge of which are 120 iron teeth. With different numbers of teeth on the two parts, only two teeth are synchronized at any one time and there is a vernier effect around the rest of the circle. This causes the motor to move only the distance of two teeth for each revolution of the magnetic field of the stator. Thus on a 60-cycle system with the stator field revolving at the rate of 3,600 times per minute,

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Written especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

the rotor revolves only 60 times per minute, the speed required for a split-second hand.

Around the inner edge of the rotor ring are 122 teeth; inside this is a second rotating iron ring of still smaller diameter with 120 teeth around its outer edge. In this second reduction of speed the first rotor becomes the stator for the second, but while the first is running forward 60 revolutions, the second is running only one, so that its net progress forward is one revolution per minute. This is the speed desired for the second hand.

Attached to the second hand rotor is a permanent horseshoe magnet which creates a new rotating field in 118 iron teeth driving still another ring with 120 teeth at the rate of one revolution per hour. This runs the minute hand. Attached to the minute hand rotor is a second permanent magnet creating a rotating field in 22 teeth and driving a 24-tooth rotor one revolution every 12 hours for the hour hand. The entire operation may be explained by saying that each rotor travels only two teeth for each revolution of its magnetic field. Obviously by changing the number of teeth, any desired speed may be obtained.

# Magnet Steels and Permanent Magnets

**A new relationship connecting the open-circuit remanence of a permanent magnet with the factors which determine its value has been found. This relationship, shown by Fig. 2 of the following article, appears to be general and valid for all kinds of magnet steel. Also, criterions of magnetic quality are presented, including a nomogram chart for permanent magnet design.**

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GENERAL STUDIES of the magnetic properties of magnet steels and permanent magnets embrace a number of related problems, prominent among them being the determination of the relation between the open circuit remanence of a permanent magnet and the various factors which determine its value. These factors include the magnetic characteristics or properties of the steel, as displayed by its hysteresis loop, and the shape and dimensions of the magnet. Of interest to the manufacturer of magnet steel are the questions of how chemical composition, and melting and rolling practise affect the magnetic and mechanical properties of the steel. The manufacturer of magnets is interested in the effect of the necessary manufacturing operations, such as heating for hot forming and annealing to increase machinability upon the flux obtainable in the finished magnet, in the tendency of the steel to warp or crack upon quenching, and in the proper hardening treatment to use.

Other special subjects may be listed, including the manner in which various influences may affect the state of magnetization of a magnet, the correlation of the microstructure and mechanical properties of a magnet steel with its magnetic properties, the determination of a suitable criterion of magnetic quality, the development of accurate and convenient testing equipment, and various other matters of greater or less importance. It is the purpose of this article to present data relating to some of the above topics which have been collected during the course of several years connection with the manufacturer of permanent magnets, both in the laboratory and in the shop.

The following symbols and notation are used in the paper. All values of $B$ are intrinsic or ferric induction.

$B_{max}$ = The value of magnetic induction corresponding to the tip of a given hysteresis loop
$H_{max}$ = the value of magnetizing force corresponding to $B_{max}$
$B_s$ = the saturation value of flux density corresponding to an infinite magnetizing force
$B_r$ = residual induction, the magnetic induction in a closed ring or infinitely long straight bar after the value of $H$ has been reduced from $H_{max}$ to 0
$H_c$ = coercive force, the value of $H$ required to reduce $B$ from $B_r$ to 0 in a ring or an infinitely long bar
$B_{rem}$ = remanence, the magnetic induction at the magnetic equator of a permanent magnet with no external magnetizing or demagnetizing force. Values of $B_{rem}$ in this paper are without pole pieces on the magnets
$L$ = the actual developed length of a magnet
$A$ = the area of cross-section of a magnet
$D$ = the equivalent diameter of a magnet = $2\sqrt{A/\pi}$
$L/D$ = the dimension ratio of a permanent magnet
$T$ = hardening temperature, absolute scale
$T_o$ = optimum hardening temperature, absolute scale
$(BH)_{max}$ = the maximum value of the product of the coordinates of the demagnetization curve for a given steel. The demagnetization curve is the portion of the hysteresis loop between $B_r$ and $H_c$

## Factors Determining Remanence of a Permanent Magnet

It was desired to determine the relationship between the remanence of a permanent magnet and the various factors which determine its value. As it was supposed that shape was one of these factors, and in order to control its influence as a variable, all tests were made upon straight bars. This form of test specimen possessed the advantages of being easily

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Based upon "Magnet Steels and Permanent Magnets—Relationships Among Their Magnetic Properties" (No. 32-24) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932.

obtainable, easily duplicated, and well adapted to the measurement of magnetic properties in a permeameter as well as to remanence measurements with a search coil.

Accordingly, a large number of straight bars was collected during the course of several laboratory investigations. Each of the bars was 12 in. in length. In the lot were bars of $^1/_8 \times 1^1/_2$ in., $^1/_4 \times ^1/_4$ in., $^3/_{16} \times ^3/_4$ in., $^1/_4 \times 1^1/_4$ in., $^3/_4 \times ^5/_8$ in. and $^3/_8 \times ^1/_2$ in. cross-sections. All available types of steel were represented, including a 0.9 per cent chrome steel, a 3.5 per cent chrome steel, a 0.85 per cent manganese steel, a 5 per cent tungsten steel, and 20 per cent, 25 per cent, and 36 per cent cobalt steels. The range in coercive force was from 40 to 260 oersteds accompanied by values of residual induction varying from 6,000 to 11,000 gausses.

## EXPERIMENTAL PROCEDURE

The test bars were hardened in the manner appropriate to each kind of steel, except that some bars purposely were quenched from a high temperature in order to secure low values of $B_r$. After hardening, the demagnetization curve for each bar was determined by means of permeameter measurements, using the Babbitt permeameter and a Grassot flux meter with lamp and scale. The control circuit of this permeameter is the conventional circuit for a ring test. All magnetic data are comparable since all of the test specimens were measured by the same instrument. (See "An Improved Permeameter for Testing Magnet Steel," by B. J. Babbitt, *Opt. Soc. Amer. Jl.*, v. 17, 1928, p. 47.)

Following the permeameter measurements each bar was magnetized as a straight bar magnet in an air core solenoid. Field strengths of over 1,000 oersteds were applied to each bar. Upon removal from the solenoid the flux density at the middle of the bar was measured by means of a search coil and the Grassot flux meter with lamp and scale. This is the quantity referred to as $B_{rem}$ in this article.

After the measurements at 12-in. lengths were completed, each bar was cut by removing 1 in. of material at each end, to successive lengths of 10, 8, 6, 4, and 2 in., except that in the case of some of the bars of larger cross-section the lengths of 10, 6, and 2 in. were omitted. Remanence measurements were made at each of the above lengths. The bars were remagnetized for each new measurement of $B_{rem}$.

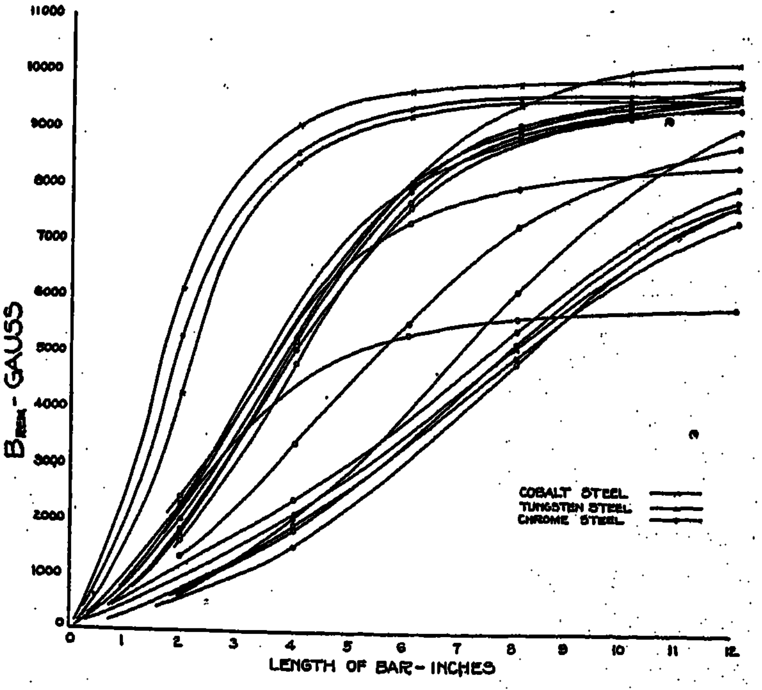

**Fig. 1. Remanence versus length for straight bar magnets of different cross-sections and materials**

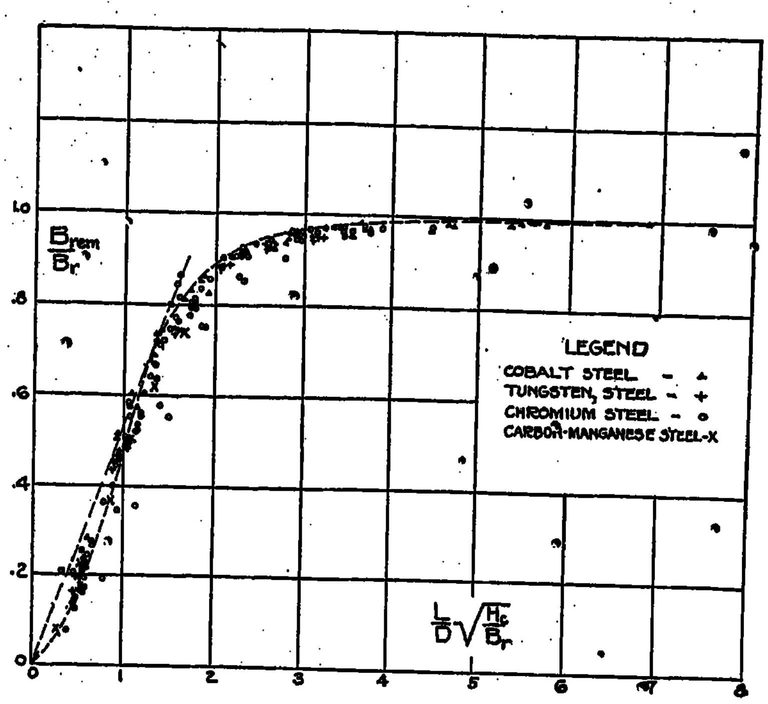

**Fig. 2. Correlation between the combinations of variables indicated, for bars of any kind of material, magnetic properties, length, and cross-section. Same data as in Fig. 1**

The foregoing experiments made available for analysis a wide range of values of the associated variables $B_{rem}$, $B_r$, $H_c$, $L$, and $A$.

## ANALYSIS OF DATA

For a number of the specimens the values of remanence versus length are plotted in Fig. 1 to show the range of values existing in different bar magnets of the same length, but of different cross-sections and materials when fully magnetized. The differences in $B_{rem}$ for a particular length of bar are due to the differences in $B_r$, $H_c$, and cross-section of the various specimens. The chief characteristics that the several curves of Fig. 1 have in common are a general resemblance in shape to a normal induction curve, and an asymptotic approach to limiting values of $B_{rem}$ as the lengths increase.

In Fig. 2 is shown the result of plotting $\frac{B_{rem}}{B_r}$ against $\frac{L}{D}\sqrt{\frac{H_c}{B_r}}$ for the same set of bars. The combination of variables $\frac{L}{D}\sqrt{H_c}$ was arrived at by a purely cut-and-try process, but it was later suggested to the writer that it would be preferable to use $\frac{L}{D}\sqrt{\frac{H_c}{B_r}}$. In either case, a surprisingly good correlation is obtained.

As shown in Fig. 2, a line drawn through the origin and tangent to the dotted curve of that figure has its point of tangency at values of $\frac{B_{rem}}{B_r}$ and $\frac{L}{D}\sqrt{\frac{H_c}{B_r}}$ of approximately 0.65 and 1.25, respectively. It will be shown later that this is the point of maximum efficiency; *i. e.*, the point at which are obtained the highest values of $B_{rem}$ or external magnetic energy per unit volume of steel. It follows that magnets should be so designed that $\frac{L}{D}\sqrt{\frac{H_c}{B_r}} = 1.25$ and $\frac{B_{rem}}{Br} = 0.65$. The nomogram of Fig. 3 was laid out on this basis. The use of this chart to design a magnet of maximum efficiency is illustrated by the dotted lines of the figure. In the case shown, a total flux in the magnet of 3,000 maxwells is desired, and a steel with a $B_r$ of 10,000 gausses and a coercive force of 54 oersteds is assumed. The correct values of $A$ and $L$ are found to be 0.461 sq. cm. and 13 cm., respectively, and the dimension ratio is 17. If the nomogram is applied to the design of other than straight bar magnets, the length given by the chart will be too great, depending upon how close the poles of the magnet come to each other.

## CRITERIONS OF MAGNETIC QUALITY OF PERMANENT MAGNET STEELS

A number of quantities determinable by magnetic measurement has been proposed at various times by different investigators for use as criterions of the magnetic quality of magnet steels. Among these may be listed $(BH)_{max}$, $B_rH_c$, $B_r/B_{max}$, $(B_rH_c)/(B_{max})$ and $B_r/H_c$. The first of these criterions is discussed in "Permanent Magnets in Theory and Practise," S. Evershed. *Instn. Elec. Eng. Jl.*, v. 58, 1920, p. 780, and v. 63, p. 725, 1925; the second in "Ein neues Material für Permanente Magnete," E. Gumlich, *Elektrotech. Zeitsch.*, v. 44, 1923, p. 147; and the last criterion is discussed in the following two articles by J. A. Mathews: "Magnetic Habits of Alloy Steels," *Am. Soc. Testing Matl. Proc.*, V. 14, 1914, p. 50; and "Retained Austenite—a Contribution to the Metallurgy of Magnetism," *Am. Soc. for Steel Treating Trans.*, Nov. 1925, p. 565.

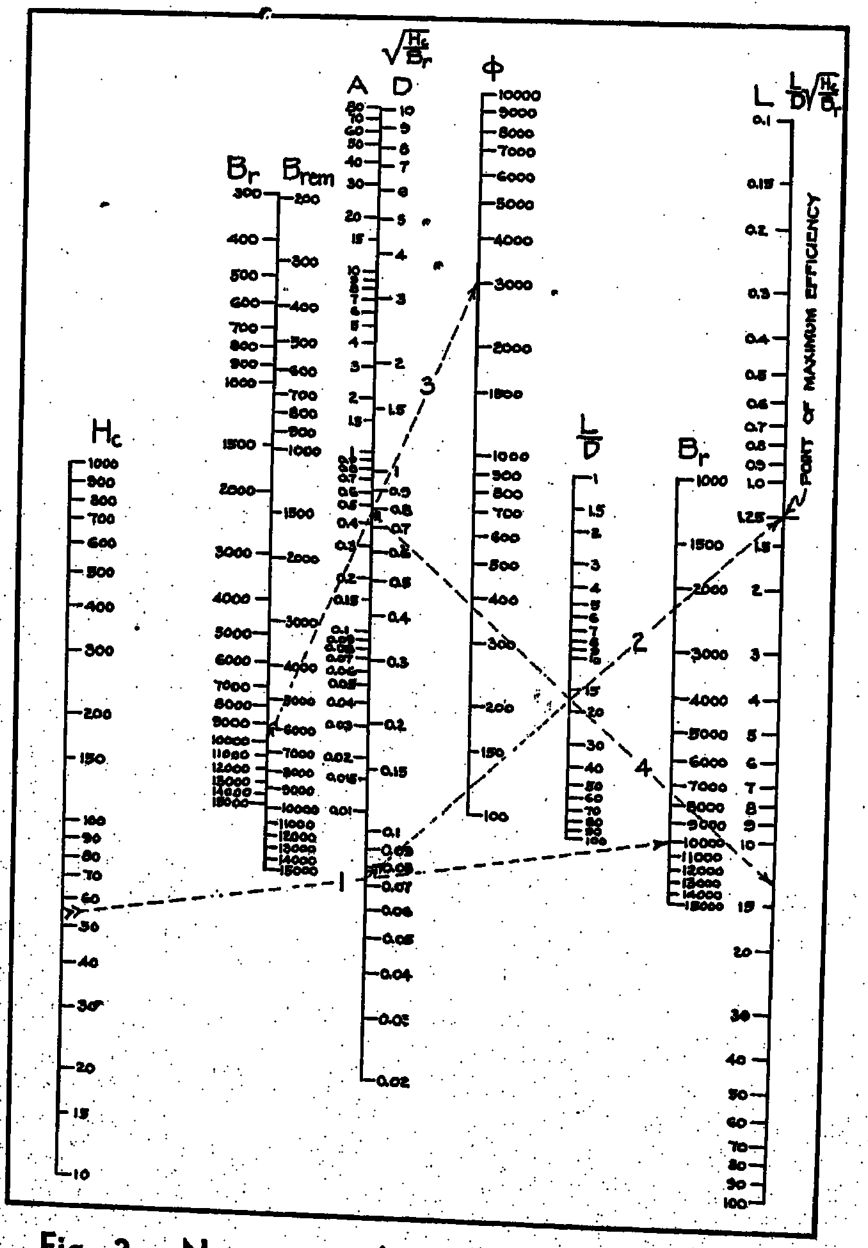

**Fig. 3. Nomogram chart for permanent magnet design for maximum efficiency. Based on the curves of Figs. 1 and 2**

The quantity $(BH)_{max}$ was proposed by S. Evershed, and his theoretical justification for it is convincing, but an experimental verification seemed desirable. Data from the bars shown in Fig. 3, and others, were used for this purpose. These data are shown on Fig. 4. For each bar there is plotted, from left to right, its demagnetization curve as determined in the permeameter, the derived curve of $BH$ versus $B$, and the curve of $B_{rem}$ in terms of length, all plotted to the same scale of $B$. Fig. 4 shows that if tangents to the curves of $B_{rem}$ versus length are drawn through the origin, the point of tangency in each case indicates the value of $B_{rem}$ and length for which the value of $B_{rem}/length$, or $B_{rem}/volume$, is a maximum. It is clearly shown that in each case these values of $B_{rem}$ coincide with the values of $B$ for which the product $(BH)$ is a maximum, thus indicating that the $(BH)_{max}$ point is the point of maximum efficiency for the magnet, while a comparison of the curves shows that the value of $(BH)_{max}$ is a measure of the efficiency or quality of the steel. It is believed therefore that the quantity

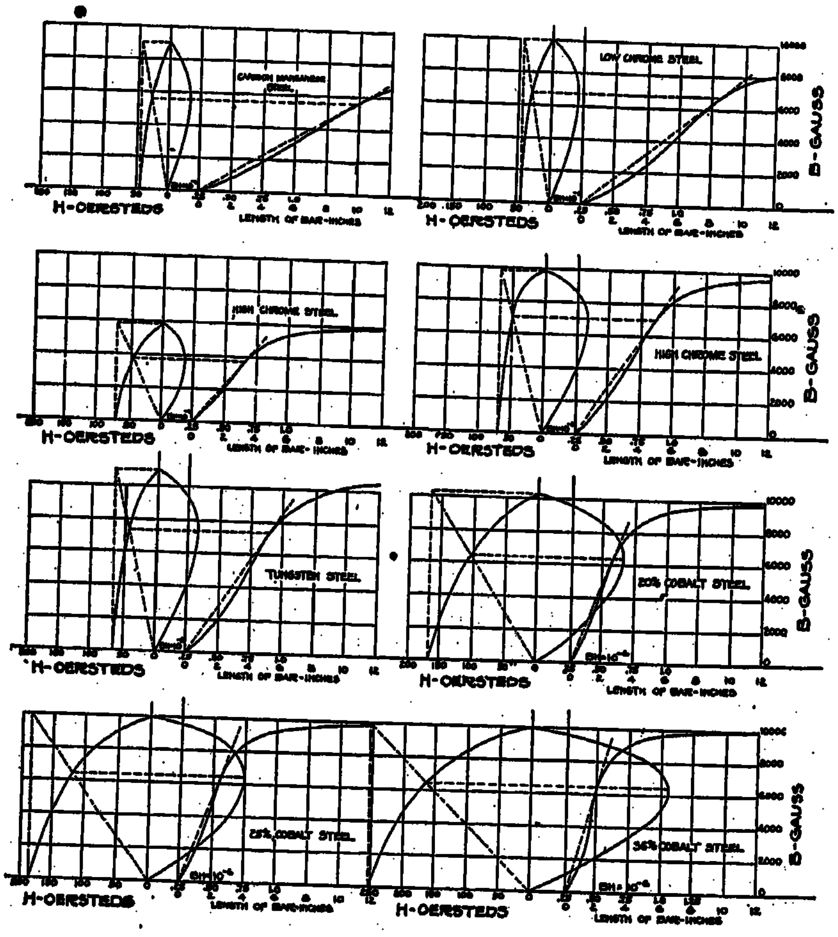

**Fig. 4. Experimental verification of validity of Evershed's criterion for magnetic quality of permanent magnet steels**

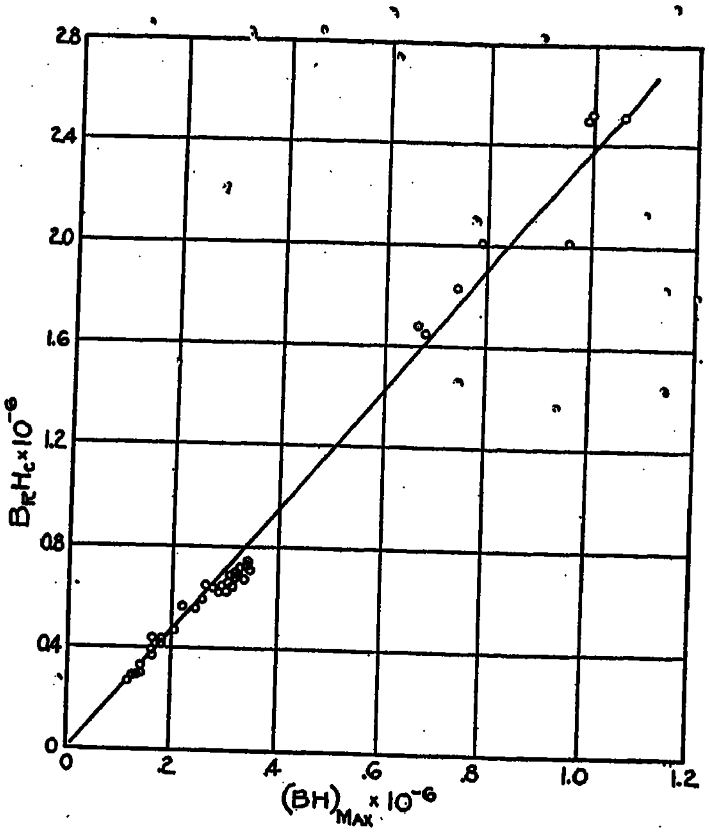

**Fig. 5.** Relation between the quantity $B_rH_c$ and Evershed's criterion $(BH)_{max}$

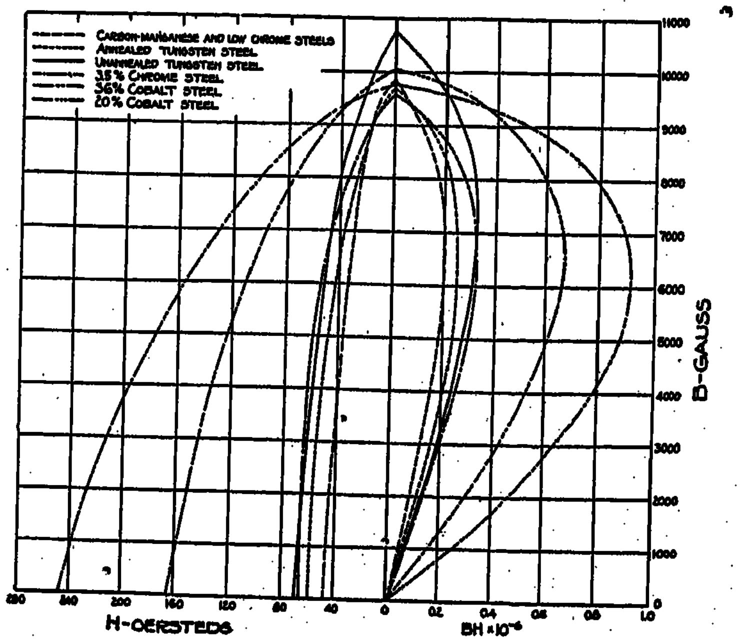

**Fig. 6.** Typical demagnetization curves and curves of *BH* versus *B* for various kinds of magnet steel

$(BH)_{max}$ furnishes a wholly reliable measure of the quality of a permanent magnet steel. It can be used to select from a choice of compositions or heat treatments the one which is the best in terms of magnetic energy in the air-gap of the magnet per unit volume of steel in the magnet. The optimum hardening temperature, previously referred to, is defined as the hardening temperature at which is obtained the maximum value of $(BH)_{max}$ for a given type of steel.

The product $B_rH_c$ is shown by Fig. 5 to bear an approximately linear relationship to $(BH)_{max}$, and as $B_rH_c$ can be determined with less effort, it is preferable for routine use as a criterion. The other quantities mentioned are all open to serious objection as being in some cases either meaningless or actually misleading. A number of typical demagnetization curves and the derived curves of $BH$ plotted against $B$ is given in Fig. 6.

# Supervisory Control for A-C. Electrified Railroads

IN ITS ELECTRIFICATION in and around Philadelphia, the Pennsylvania Railroad has made use of two installations of supervisory control for the remote operation of high voltage a-c. step-down substations. In a current A.I.E.E. paper (see footnote) C. P. West (M'28) Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and H. C. Griffith, Pennsylvania Railroad Company, Philadelphia, Pa., describe some of the features of the installation and relate in detail how some of the difficulties encountered were solved.

When the electrification was put into service, interference with the supervisory equipment was experienced from induced voltage in the control wires when the trolley circuits were fed from one end. This interference was evidenced by chattering of the relays, and flashing over, and sometimes destruction, of the protector tubes; in case of trolley fault, fuses were blown.

After attempting by several other means, to obviate the disturbing effects of the induced voltages, one of the installations was rebuilt using a new method of control known as the *visicode* system, brought out by the Westinghouse company. This scheme utilizes only two line wires and operates by means of d-c. unidirectional impulses; it is ideally suited to the limiting of effects of low frequency induction. A special reactor connected in each end of the control system line is said to be the key to the successful application of this circuit. With this arrangement a low induced current can flow continuously in the two supervisory, line wires without flashing the protector tubes or interfering with operation. A high quality of operation has been obtained since the rebuilding of this installation. In the second installation, the synchronous visual set originally installed has a rather short line circuit and is not so closely located to contact line circuits; this original equipment continues to give good operation.

When these types of supervisory control equipment have been adjusted properly, they are said to operate with very little maintenance; where the equipment is in a clean neighborhood and is operating satisfactorily, inspection periods can be extended to as long as four months. In conclusion the authors state that, "The results obtained by the Pennsylvania Railroad have shown that when the substations are located where control points are so distant that the installation of direct control cables is not economical, control can be adequately obtained by the use of proper supervisory equipment.... It may be safely stated that supervisory control is destined to play an increasingly important part in future railroad electrification."

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Abstracted from "Supervisory Control for A-C. Electrified Railroads" (No. 31-93) by C. P. West and H. C. Griffith, presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

# Standard Decrement Curves

**Standard decrement curves in use for a number of years in the calculation of power system voltages and currents under fault conditions now have been revised and are presented herewith. Their use enables the determination of the magnitudes of voltages and currents for various intervals of time subsequent to the occurrence of a fault.**

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APPLICATION of circuit breakers and relays on power systems frequently requires a determination of the magnitude of voltages and currents under fault conditions for various intervals of time measured from the instant of the application of the fault. The decay of fault current from initial to sustained values commonly is determined by means of decrement curves. A standard set of decrement curves was published for the first time in 1918 (see reference 1 in bibliography). These were revised in 1923, and published in the N.E.L.A. Relay Handbook (1926) and in various manufacturers' publications.

In the past eight years there has been considerable progress in the analysis of transients in synchronous machines. Furthermore, the method of symmetrical components has come into general use for the calculation of unbalanced faults. These developments in theory, together with the increased knowledge of machine constants, have made desirable a new set of decrement curves. Such a set now has been prepared and is given in Figs. 1 and 2. These curves have been approved by the National Electrical Manufacturers Association.

## REFINEMENTS SECURED

A single decrement for the a-c. component of fault current was assumed for the 1923 decrement curves. The new curves take into consideration the fact that the a-c. component is made up of two exponential terms and the fact that the transient time constant varies with system reactance. The method of using the curves includes a means to give more accurate results in case the time constants of machines differ appreciably from the assumed average figures upon which the curves are based.

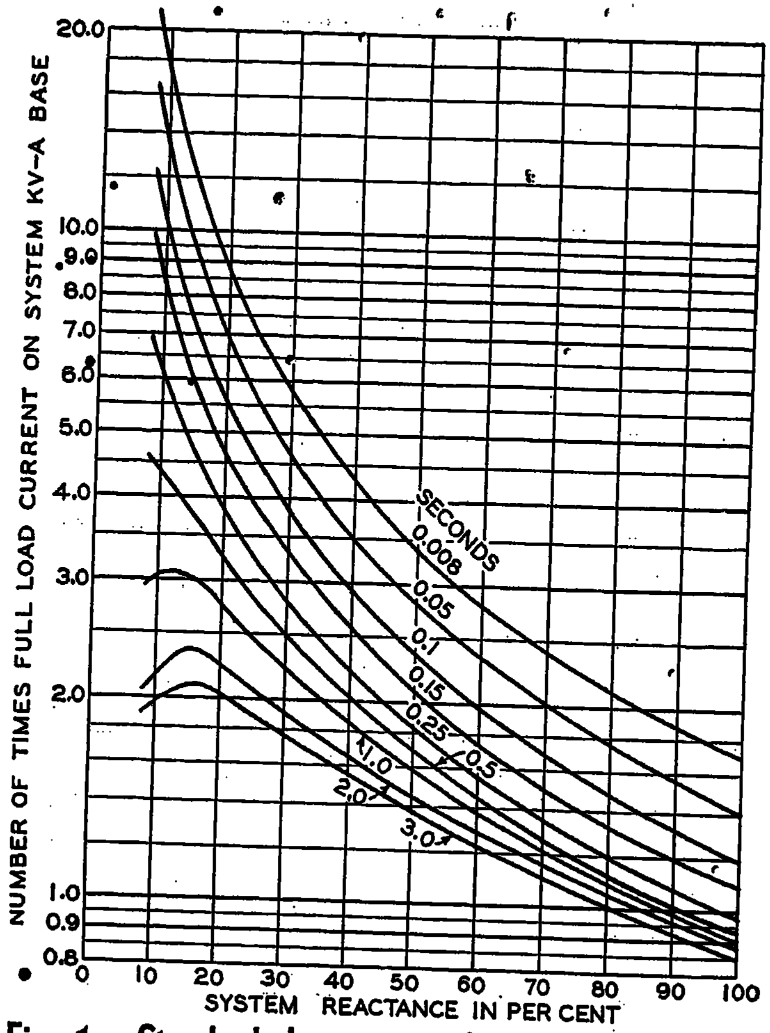

Fig. 1. **Standard short-circuit decrement curves for synchronous machines**

System reactance must be based on system kva. and not on the particular kva. chosen as a base for calculations. System kva. is connected synchronous capacity in kva.

These curves are based on $T'_{do} = 5$ sec. For other values multiply actual times by $\frac{5}{T'_{do}}$ to get equivalent times to use in curves.

For three-phase short circuit—
  Reactance—Use system reactance to the point of fault
  Times full load (normal) scale—use scale reading
For line-to-line short circuit—
  Reactance—Use two times system reactance for three-phase fault
  Times full-load (normal) scale—Multiply scale reading by $\sqrt{3}$
For line-to-ground short circuit—
  Reactance—Use $(2x_1 + x_0)$ or

$$\frac{3 \times (\text{initial three-phase short-circuit current})}{(\text{initial line-to-ground short-circuit current})} \times \text{system reactance for three-phase fault}$$

  Times full-load (normal) scale—Multiply scale reading by 3

Three separate groups of curves, one for each type of fault, namely, three phase, line-to-line, and line-to-ground, were included in the 1923 curves. The new decrement curves include only a single set which, however, is applicable to the same three types of faults. This is feasible because the new curves are based upon the method of symmetrical components. The old curves assume equal initial values of line-to-line and three phase currents whereas the present curves are plotted for the more usual ratio of 0.866. The old curves for line-to-ground faults were re-

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Based upon "Standard Decrement Curves" (No. 32-53) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932.

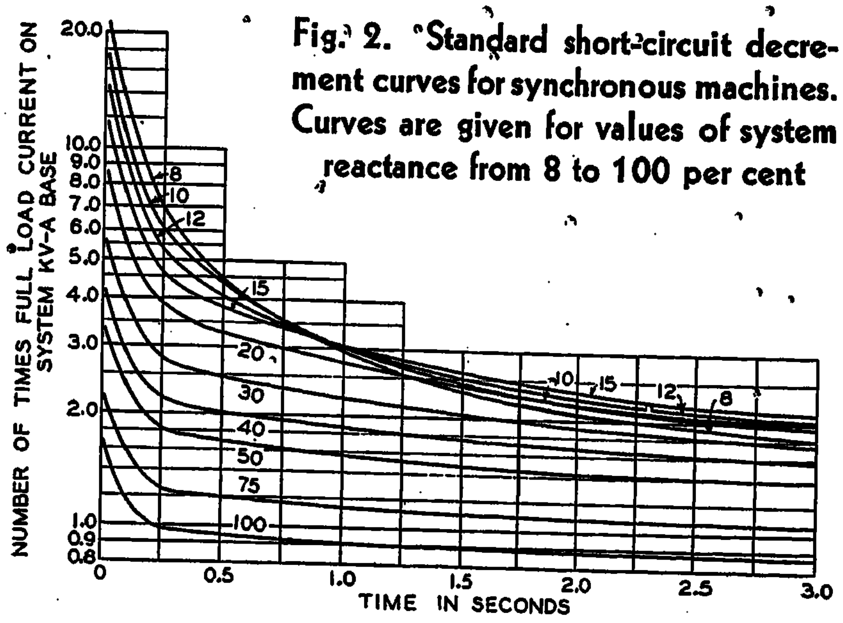

Fig. 2. Standard short-circuit decrement curves for synchronous machines. Curves are given for values of system reactance from 8 to 100 per cent

stricted to the particular case of a fault on the terminals of one or more generators all the neutrals of which were solidly grounded; the new curves were not restricted in this respect.

No distinction was made between machines with and without damper windings in the 1923 curves, while the present set has been designed to apply particularly to salient pole machines with amortisseurs, and to turbine-alternators. They therefore give inaccurate results for the first 0.2 sec. for salient pole machines without damper windings and are supplemented by a method of calculation which gives the initial value of short-circuit current accurately for these machines.

## BASIC ASSUMPTIONS

The basic assumptions from which the new curves have been derived are as follows:

1. Immediately preceding the short circuit the generators are operating at rated voltage and kilovoltamperes at 80 per cent power factor.

2. No automatic voltage regulator is used.

3. The actual system subjected to fault may be represented by a single equivalent generator of the same total rating and an external reactance.

4. The load is located at the machine terminals; the machine reactance is taken as 15 per cent unless the total reactance is less than 15 per cent, in which event all the reactance is assumed to be in the machine.

5. The short circuit occurs on an unloaded feeder.

6. The short circuit occurs at the point of the voltage wave which corresponds to maximum possible instantaneous current.

7. All resistance in the circuit including the resistance of the fault is neglected.

8. All the machine e.m.f.'s are in phase.

9. The machine reactances and time constants are those of representative modern machines. Of particular importance is the relation between transient and subtransient reactance of machines as shown in Fig. 3.

## APPLICATION OF STANDARD DECREMENT CURVES

The decrement curves of Figs. 1 and 2 give the r.m.s. total current expressed in terms of "times normal current" with total connected synchronous capacity in kilovoltamperes as a base. The same data are given in both figures, system reactance in per cent being used for the abscissas of Fig. 1, while elapsed time in seconds is used as the abscissas of Fig. 2. The curves of either figure may be used, depending upon convenience. The instructions for use given below Fig. 1 apply also to Fig. 2.

The reactance to be used with the curves for any kind of a fault may be obtained by means of analytical calculation, by the use of the calculating board, or, if the initial values of symmetrical short-circuit currents happen to be known from other sources, indirectly by substitution in the formulas below Fig. 1. In order to choose the proper decrement curve it is essential that the reactance used to select a curve in Fig. 2, or a line in Fig. 1, be expressed as a per cent of the total connected synchronous capacity in kilovoltamperes rather than as is common practise, an arbitrary value conveniently chosen to expedite system calculations.

If the system open circuit time constant $T'_{do}$ referred to the point of fault is known to be other than 5.0 sec., the time scale of the curves may be corrected to conform to it by means of the formula given below Fig. 1. Other information on this subject may be found in references 4 and 5.

## THREE PHASE SHORT CIRCUIT

The reactance to be used to select the proper decrement curve for a three phase fault, is what is commonly spoken of as the "system reactance" referred to or viewed from the point of fault. It is the reactance used with the decrement curves formerly published. When determining this reactance it is important that synchronous machines be represented by their subtransient reactances, and that all loads other than synchronous be neglected. Proper account has been taken of these loads for the average system in deriving the decrement curves.

The subtransient reactance just mentioned is the reactance to use in determining the r.m.s. initial

Table I—Typical Range and Average Values of Constants for Three Phase 60-Cycle Synchronous Machines

| | $x_d$ | $x_d''$ | $x_2$ | $x_0$* |
|---|---|---|---|---|
| Turbine-generators | 0.95 to 1.45 (avg. 1.10) | 0.07 to 0.17 (avg. 0.12) | $= x_d''$ | 0.01 to 0.14 (avg. 0.03) |
| Salient pole motors and generators (with amortisseurs) | 0.60 to 1.45 (avg. 1.10) | 0.13 to 0.35 (avg. 0.22) | $= x_d''$ (nearly) | 0.02 to 0.20 (avg. 0.06) |
| Waterwheel generators (no amortisseurs) | 0.60 to 1.45 (avg. 1.10) | $0.85x_d'$ | 0.30 to 0.70 (avg. 0.50) | 0.04 to 0.22 (avg. 0.07) |
| Condensers | 1.50 to 2.20 (avg. 1.80) | 0.18 to 0.38 (avg. 0.25) | 0.17 to 0.37 (avg. 0.24) | 0.02 to 0.15 (avg. 0.08) |

NOMENCLATURE

$x_d$ = direct axis synchronous reactance (unsaturated)
$x_d'$ = direct axis transient reactance (saturated)
$x_d''$ = direct axis subtransient reactance (saturated)
$x_1$ = positive sequence reactance
$x_2$ = negative sequence reactance
$x_0$ = zero sequence reactance (saturated)

SUPPLEMENTARY DATA

For test data of specific machines, refer to bibliography item 14.
$x_d'$ = for waterwheel generators (saturated) = 0.20 to 0.45 (avg. 0.35)
$x_d''$ = for turbine-generators and salient pole machines with amortisseurs (saturated) from Fig. 3

*$x_0$ varies so critically with armature winding pitch that the average values given are not very dependable.

value of the a-c. component of short-circuit current. It includes the effect of induced currents in damper windings, etc., which have a very rapid decrement. The transient reactance on the other hand determines the a-c. component when the rapidly decaying component is neglected, while the synchronous reactance is used to determine sustained values of current.

Means for obtaining the system reactance referred to the point of fault, and the corresponding short-circuit current has been developed fully in other papers[6–11] and is not discussed here. In case synchronous machine reactances or time constants are not known, Table I and Figs. 4 and 5 may be used as a guide in selecting reasonable values.

The system reactance referred to the point of fault assists in the selection of the proper decrement curves which gives the three phase r.m.s. short-circuit current or kva. in "times normal" at any time after the occurrence of the short circuit, subject to the assumptions previously given.

## Line-to-Line Short Circuit

For a line-to-line short circuit the fault current is determined by the use of the standard decrement curves of Figs. 1 and 2 in the same manner as the three-phase short-circuit current by using a reactance equal to twice the system reactance (the value used for three-phase short-circuit calculation) and multiplying the resulting current in times normal read from the curves by $\sqrt{3}$. This rule results from the theory of symmetrical components,[7,8,9,11] assuming the negative phase sequence reactance of the system as measured from the point of fault to be equal to the system reactance $x_1$. Where the negative phase sequence of the system is known, more accurate results may be obtained by using a reactance equal to the sum of the system reactance $x_1$ and the negative phase sequence system reactance $x_2$ instead of twice the system reactance $x_1$. The negative phase sequence reactance of the system is obtained in the same manner as the system reactance $x_1$ except that the negative phase sequence reactance of the machines is substituted for the subtransient reactance of machines.

## Line-to-Ground Fault

For line-to-ground faults, the decrement curves of Figs. 1 and 2 still may be used, provided the ratio of the instantaneous values of three-phase fault current to line-to-ground fault current, or the proper value of reactance, is known. For this case the reactance may be taken as three times the system reactance ($3\ x_1$) multiplied by the ratio of the three phase current to the line-to-ground short-circuit current. Ordinarily the line-to-ground short-circuit current must be calculated by the method of symmetrical components or the reactances for the different sequences used as outlined in the paragraph following. At any time the line-to-ground current will be equal to three times the value of "times normal current" read from the decrement curves using the above values for system reactances.

**Table II—Initial R.M.S. Alternating (Symmetrical) Current**

| | | | | | |
|---|---|---|---|---|---|
| Reactance on decrement curve | 8 | 10 | 12 | 15 | 20 |
| Initial symmetrical current | 12.3 | 9.96 | 8.38 | 6.88 | 5.11 |
| Reactance on decrement curve | 30 | 40 | 50 | 75 | 100 |
| Initial symmetrical current | 3.37 | 2.52 | 2.01 | 1.33 | 1.00 |

The value of reactance to be used with the curves for a line-to-ground short circuit may be determined, using the method of symmetrical components, the reactance being taken as the sum of the positive, negative, and zero sequence reactances of the system ($x_1 + x_2 + x_0$) as measured from the point of fault. For ordinary calculations it is sufficiently close to use a reactance equal to $2\ x_1 + x_0$, where $x$ is the system reactance used for three-phase short-circuit calculations and $x_0$ is the zero phase sequence reactance of the system. The zero phase sequence reactance may be obtained in a manner similar to that used for the determination of the system reactance for three phase short circuits by changing the reactances in accordance with the following rules:

| | |
|---|---|
| Ungrounded transformers | = ∞ |
| *Grounded $\Delta$-$Y$ transformers | = ordinary reactance to neutral on $Y$ side and open-circuited on $\Delta$ side |
| Neutral impedance | = 3 × actual impedance in neutral |
| Single circuit aerial lines (no ground wires) | = 3.5 × ordinary reactance |
| Double circuit aerial lines (no ground wires) | = 5.5 × ordinary reactance of double line |
| Single-circuit aerial lines (copper or aluminum ground wires) | = 2.0 × ordinary reactance |
| Double circuit aerial lines (copper or aluminum ground wires) | = 3.0 × ordinary reactance of single line |
| Cables, three phase | = 3 to 5 × ordinary reactance |
| Cables, single phase | = 1.0 × ordinary reactance |

*Replace by circuit which permits current to flow from $Y$ side to ground but not on $\Delta$ side.

For auto-transformers, grounding transformers, and other special apparatus, refer to papers and articles which discuss the determination of the zero phase sequence impedance in more detail.[8,12,13]

## Minimum Fault Current

For certain relay applications it is sometimes necessary to know the total r.m.s. alternating fault current, *i. e.*, with no d-c. component, rather than the maxi-

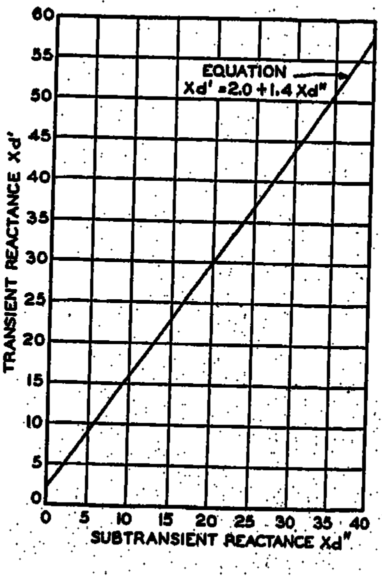

**Fig. 3. Relation between $x_d'$ and $x_d''$ (saturated values) for three phase synchronous machines**

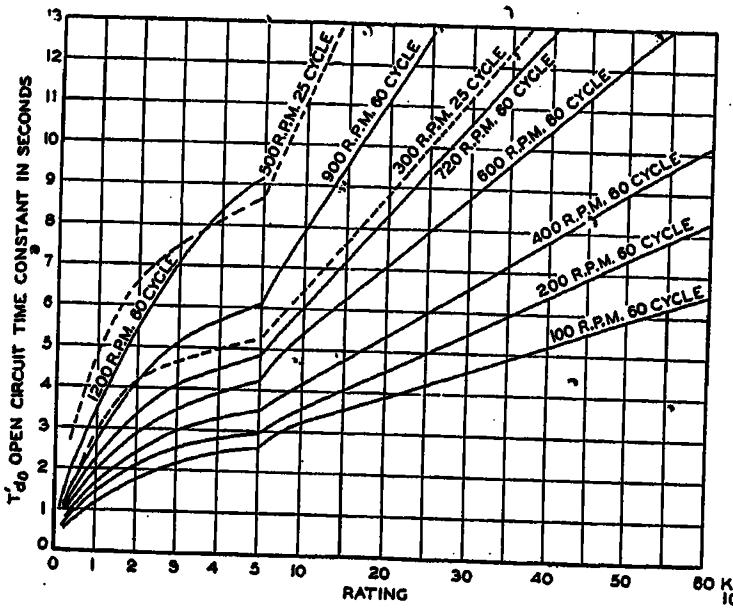

**Fig. 4. (Left)** Open-circuit time constants of a-c. generators and motors

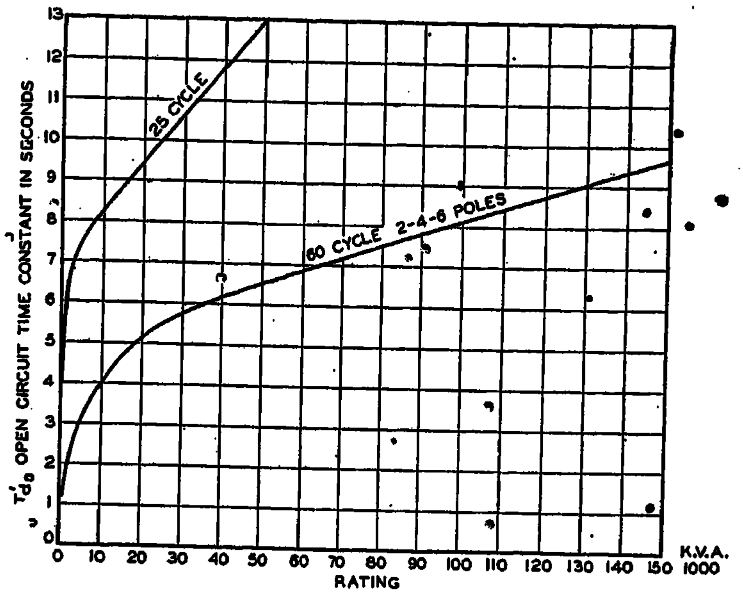

**Fig. 5. (Right)** Open-circuit time constants of turbine generators

mum current at any time as given by the standard decrement curves which are based upon an asymmetrical fault. The initial r.m.s. alternating (symmetrical) currents for values of system reactance are given in Table II.

As the asymmetrical component is negligible after 0.3 sec., the r.m.s. alternating (symmetrical) current for any time less than 0.3 sec. may be obtained by interpolation between the initial value obtained from the above table and the curve values at 0.3 sec. Satisfactory results can be obtained readily by sketching in a curve starting from the initial r.m.s. alternating (symmetrical) current and making it tangent to the corresponding standard decrement curve at 0.3 sec.

### SALIENT POLE MACHINES WITHOUT DAMPERS

Where salient pole machines without damper windings supply the short-circuit current the standard decrement curves give good results after 0.2 sec., provided that for these machines the equivalent subtransient reactances are obtained from the known transient reactances by means of the relation given in Fig. 3; however, the initial values indicated by standard decrement curves may be 30 per cent too high. If more accurate values of initial current are desired, it is necessary to make a separate calculation of the system reactance using the actual value of the subtransient reactance of the salient pole machines without damper windings instead of the equivalent value obtained from the transient reactance by means of the relation given in Fig. 3. A curve readily may be sketched between the new initial point and the 0.2 sec. point on the standard decrement curve corresponding to the equivalent subtransient reactance of Fig. 3.

The subtransient reactance of machines without damper windings generally has been taken as equal to the transient reactance. However, there is an appreciable subtransient component in the short-circuit current of such a machine due to the damping action of the pole rivets and other closed circuits, and also due to the rapidly disappearing effects of saturation. The test data available indicate that the subtransient reactance of a machine without damper windings should be taken as about 85 per cent of the transient reactance.

### LIMITATIONS OF THE STANDARD CURVES

There are certain limitations in the application of standard decrement curves that should be recognized. The decrement curves with the supplementary methods will give safe values for circuit breaker application, except possibly in unusual cases. However, for relay application, it is frequently insufficient to know that the current does not exceed a particular maximum value but instead it is important to know the minimum current values under given fault conditions. In deriving the curves, it was assumed that the system could be replaced by a single equivalent generator. If the initial currents supplied to the fault by the several machines are not in proportion to their ratings, then the division of the sustained currents will not be proportional to the initial current division. Furthermore, the total current will actually be considerably smaller. For example, if a large part of the initial short-circuit current is supplied by a machine the rating of which is a small fraction of the total kva., the curve may give a sustained value that is more than 100 per cent too high. It has been assumed also that the system is fully loaded, so that if the decrement curves are used in the case of a system which is only partially loaded, it is evident that the sustained current will be less than the values given by the curves. Further it has been assumed that all of the generated e.m.f.'s are in phase. Departures under operating conditions from this assumption result in smaller values of current.

When voltage regulators are used there will be a tendency to increase the current over that given by the decrement curves. For the first 0.2 sec. the fault current will ordinarily be unaffected but the sustained current may be increased in proportion to the ratio of the maximum exciter voltage to the nominal exciter voltage corresponding to rated voltage and kva. at 80 per cent power factor. For ordinary excitation systems, *i. e.*, where quick response systems are not used, the sustained currents may be increased as much as 50 per cent by the action of the voltage regulators.

In general, for systems with characteristics radically different from the assumptions upon which the standard curves are based it may be necessary to use more accurate methods of calculation. (*Editor's note*—Steps toward the refinement of such methods have been taken and are presented in references 2 and 3.)

## EXAMPLES

The following two numerical examples illustrate the manner in which the standard decrement curves are used. For the first illustration let it be assumed that the system voltage is 66 kv. and the following data have been obtained either analytically or by use of a calculating board:

Total connected synchronous capacity = 5,500 kva.
Initial r.m.s. alternating component, three-phase short-circuit current...... = 480 amperes (55,000 kva.)
Initial r.m.s. alternating component of line-to-ground short-circuit current... = 570 amperes (65,000 kva.)
(The short-circuit kva. for a line-to-ground fault is equal to $\sqrt{3}$ times the product of fault current and system voltage.)

The system reactance is then

$$\frac{5{,}500}{55{,}000} \times 100 = 10 \text{ per cent}$$

The three-phase short-circuit current at 0.3 sec. is desired. Referring to Fig. 2 and following along the 10 per cent reactance curve to 0.3 sec. time it is found that at this time the short-circuit current or kva. is 5.6 times normal. Thus the short circuit kva. at 0.3 sec. is

$$5.6 \times 5{,}500 = 30{,}800 \text{ kva.}$$

Since the short circuit occurred on a 66-kv. line, the corresponding short-circuit current is

$$\frac{30{,}800}{66 \times \sqrt{3}} = 269 \text{ amperes}$$

If the equivalent open-circuit time constant of the system is 3.0 sec. instead of 5.0 sec. then the time to be used with the curves corresponding to 0.3 sec. is in accordance with the formula given below, Fig. 1.

$$0.3 \times \frac{5.0}{3.0} = 0.5 \text{ sec.}$$

For this value of time a value of 4.3 times normal is read from the curve, and the three-phase short-circuit kva. at 0.3 sec. becomes

$$4.3 \times 5{,}500 = 23{,}600 \text{ kva.}$$

For a line-to-line short circuit the reactance to be used with the curves is twice the system reactance used to find the three-phase short-circuit kva. It is

$$10 \text{ per cent} \times 2 = 20 \text{ per cent}$$

This reactance at 0.5 sec. on the curve of Fig. 2 gives 3.3 times normal, which when multiplied by $\sqrt{3}$ is 5.72 times normal. The magnitude of the line-to-line short circuit at 0.3 sec. is then

$$5.72 \times 5{,}500 = 31{,}500 \text{ kva.}$$

The line-to-ground short-circuit reactance is found from the formula on the curve sheet as

$$\frac{3 \times 65{,}000}{55{,}000} \times 10 = 35.5 \text{ per cent}$$

The line-to-ground short-circuit kva. is found by interpolation for 0.5 sec. to be 2.2 times normal which multiplied by 3 gives 6.6 times normal as the line-to-ground short-circuit kva. at 0.3 sec., *i. e.*,

$$6.6 \times 5{,}500 = 36{,}300 \text{ kva.}$$

Since this fault occurred on a 66-kv. line the line-to-line ground short-circuit current at 0.3 sec. is

$$\frac{36{,}300}{66 \times \sqrt{3}} = 317 \text{ amperes}$$

As a second illustration, a system having only water-wheel generators without amortisseur windings will be considered. The system has a total synchronous capacity of 8,000 kva., a transient reactance of 38 per cent, of which 15 per cent is external, and an open-circuit time constant of 5 sec. The three-phase short-circuit currents at 0.1 and 2.0 sec. are desired.

The curves of Fig. 2 give the decrement after 0.2 sec. quite accurately if the proper transient reactance is used to select the curve. Referring to Fig. 3 the subtransient reactance corresponding to a machine transient reactance of 23 per cent is 15 per cent. The system equivalent subtransient reactance is

$$15 \text{ per cent} + 15 \text{ per cent} = 30 \text{ per cent}$$

Using the 30 per cent curve of Fig. 2, the times normal value at 2.0 sec. is found to be 1.9. Thus the three phase short circuit is

$$1.9 \times 8{,}000 = 15{,}200 \text{ kva.}$$

The more accurate method is necessary in determining the short-circuit current at 0.1 sec. By referring to Table I it is found that the subtransient reactance of a waterwheel generator without an amortisseur is about 85 per cent of its transient reactance. So this equivalent waterwheel generator machine has a subtransient reactance of

$$23 \times 0.85 = 19.6 \text{ per cent}$$

Adding to this the external reactance, the system subtransient reactance which determines the initial short-circuit current is obtained:

$$19.6 + 15 = 34.6 \text{ per cent}$$

By interpolation between the curves of Fig. 2, the initial three phase short circuit is found to be 4.8 times normal. From the curve sketched in connecting this value to the 30 per cent curve at 0.2 sec. it is found that the three-phase short-circuit kva. at 0.1 sec. is 3.7 times normal. It is

$$3.7 \times 8{,}000 = 29{,}600 \text{ kva.}$$

The short-circuit currents may be found as in the preceding problem.

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# A-C. Supervisory Control System

**A supervisory control system operating entirely on alternating current and possessing great reliability is described in this article. With a suitable switchboard arrangement, the operator is said to be able to visualize switching conditions at a glance; the system has the further advantage of employing only equipment with which operators are familiar.**

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BECAUSE of the rapid extension of electric power systems and the progress of electrification of railroads, the control engineer has been called upon to provide solutions to increasingly intricate control problems. Coordination between those operations led to their concentration into the hands of a single operator or dispatcher, and the adoption of automatic and of remotely controlled substations. In order to be able to control equipment located at appreciable distances it was necessary to reduce to a minimum the number of wires required for transmitting a large number of different signals; this led to the adoption of different designs of supervisory control. At the time of the adoption of those systems it was felt that only a d-c. system operating from a battery would be sufficiently reliable, as a system directly supplied by the power lines to be controlled would be affected by disturbances in these lines, at times when supervision most urgently is required.

Operating on alternating current the system described in this article thus is something of an innovation. Different means may be used for insuring a dependable a-c. supply: The supply can be obtained in any of the interconnected stations, and may consist of a small motor-generator set, supplied from the station battery. This may be dispensed with, however, if the house supply of a generating station can be made available, as this supply is not affected by any disturbances to the high voltage lines feeding the controlled substations. Another alternative is to obtain voltage from the power lines at the controlling station and at each controlled substation if these latter are fed from the same power system. In this case the supervisory system will be dead only if the power fails simultaneously at all feeding points. In either case disturbances in the low voltage side of the controlled substations will not affect the supervisory system.

In networks with many internal connections it may be felt that the presence of normal voltage on the substation bus may be depended on at all times, so that each station can be supplied independently of each other, thereby eliminating the necessity of running two supply line wires between stations; a single return wire then can be used instead. In some cases an additional degree of safety can be obtained if a supervisory control system of this kind is supplied from one high voltage network while controlling another independent network. Each individual case will indicate the best current supply to be used.

Great reliability has been the attribute most sought in the development of this control system. It employs equipment of a sturdy type used in the past in relay applications; such apparatus is little subject to disturbance by even severe inductive interference, and further it can be protected from disturbances by the insertion of insulating transformers into the lines. The system is of the synchronous selector type, each station comprising one selector, started from its rest position when an operation is to be performed, and returned to this position after the operation has been completed. In Fig. 1 is shown diagrammatically the connections of a controlling station *I* and a controlled station *II* connected by five line wires. Equipment sufficient

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Based upon "An A-C. Supervisory Control System" (No. 31-91) presented at the A.I.E.E. summer convention, Asheville, N. C., June 22–26, 1931.

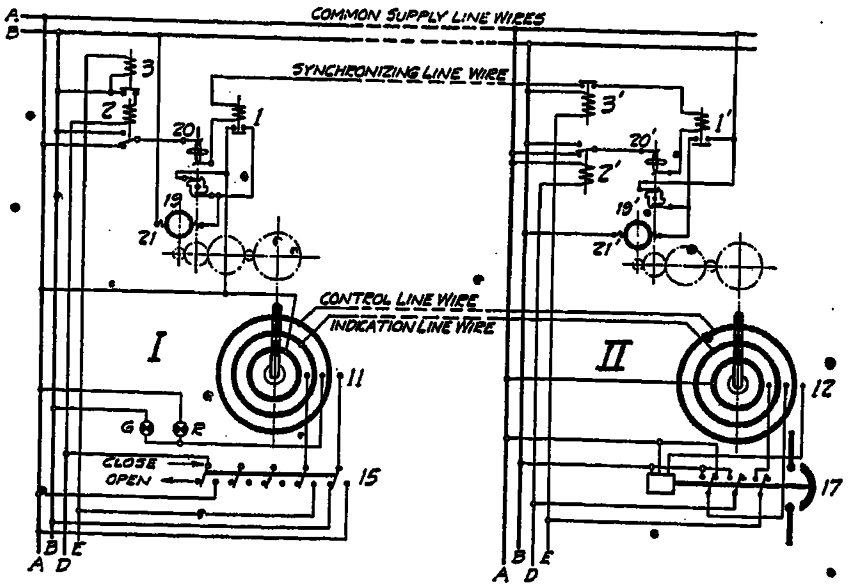

Fig. 1. Simplified diagram of a-c. supervisory system

only for illustrating the principle of operation of the selectors and the control of a circuit beaker is included in this diagram.

Selectors have been built with as many as 67 operating positions. These selectors are driven by a motor of remarkable simplicity and reliability, and one which has proved its worth in many years of service in central station and substation relays. (See Fig. 2.) It has been found that an operating time of from $^1/_3$ to $^1/_2$ sec. per step permits satisfactory operation of all the relays.

Referring to the simplified circuit of Fig. 1, the controlling station is assumed to be provided with an a-c. source supplying auxiliary busbars *A* and *B* and, over supply line wires, a set of similar auxiliary busbars, in the controlled station. Each station possesses also a starting bus *D* and a stopping bus *E* for controlling the operation of the selectors. If the selector arms are assumed to be in the rest position, as shown in Fig. 1, and it is desired to close circuit breaker *17*, control switch *15* of the circuit breaker is moved to the "close" position. This control switch is provided with several contacts, one of which connects starting bus *D* to busbar *A*, thereby energizing starting relay *2*. Until the starting relay is energized, the synchronizing line wire is connected to busbar *A* in both stations *I* and *II*, and therefore is without current. When the starting relay *2* operates, it connects one end of the synchronizing line to busbar *B;* the synchronizing line thus receives current, energizing selector relays *1* and *1'*. The latter connect to the busbars the selector motors *21* and *21'*, which start to rotate. This rotation is transmitted to contacts *19* and *19'*, which first connect the motors directly to the busbars, to contacts *20* and *20'* which open the synchronizing line, and through the two-tooth pinions to the selector arms which move to the first step. When this step is reached, contacts *20* and *20'* first reclose the synchronizing line, and contacts *19* and *19'* then disconnect the motors from the busbars. Starting relay *2* still being closed, another current impulse is sent over the synchronizing line, reenergizing selector relays *1* and *1'* before contacts *19* and *19'* open, thereby initiating another one step motion of the selector arms through the same sequence of operations.

Each selector arm thus can leave a step only if this step also has been reached by the other selector arm; motion of the selectors is obtained independently until they both again reach the following step. If one of the selectors should fail to operate while between two steps, the other selector would be unable to proceed; means are provided also for stopping the selectors if either one should jam on a step or fail to return to its rest position. In normal operation the two selector arms proceed over the

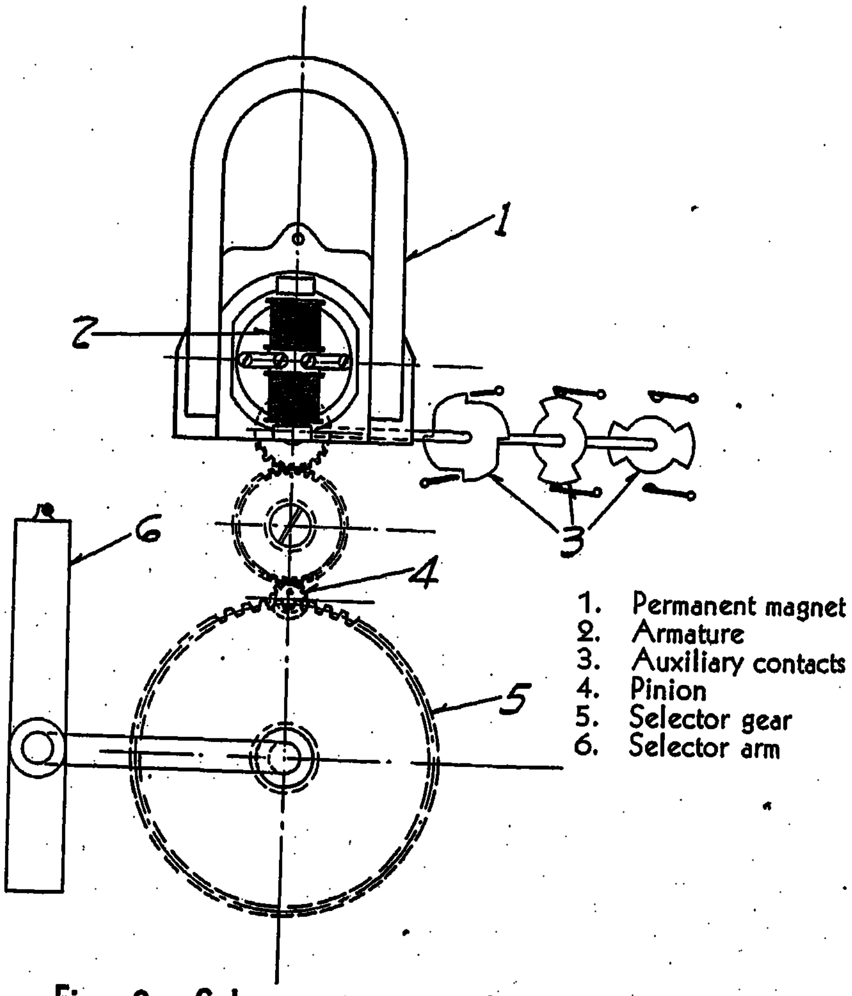

Fig. 2. Selector motor and driving mechanism

successive steps without stopping until both reach the step assigned for the control of circuit breaker *17*.

One of the brushes of selector *II* then connects busbar *A* through the control switch to the stopping bus *E;* stopping relay *3* then is energized and opens the circuit of starting relay *2*, which reconnects the synchronizing line to busbar *A* as when the system was at rest. Selector relays *1* and *1'* therefore are deenergized and the selector arms remain at standstill. Another brush of selector *II* then sends the control impulse over the control line wire and over selector *12* to the control circuit of the circuit breaker, causing it to close; the circuit breaker auxiliary contacts then send an indicating signal back over the indicating line wire.

When the circuit breaker trips automatically, it energizes starting relay *2'* which sets the two selectors in motion, in the same manner as when starting relay *2* is energized. The two selectors are stopped by means of stopping relay *3'* the return indication then being transmitted over the indicating line wire. The operator must acknowledge the tripping by moving the breaker control switch to the "open" position, and suitable relays prevent the initiation of a control operation or even the completion of an operation initiated before the tripping, until such acknowledgment is made. Thus when the operator wishes to perform a control operation, he is assured positively that while that operation is being completed, the equipment which this operation does not affect will still be in the condition shown by the indications on his switchboard. At the same time, this condition can be the result only of operations either initiated or acknowledged by himself by means of his control switches. In this manner the danger of the operator becoming confused and performing undesired operations is reduced to a minimum.

After an operation is completed, the selectors are returned by suitable relays to their rest positions. In addition to the foregoing provisions, proper control of a circuit breaker requires means for preventing automatic reclosing after tripping and consequent "pumping"; to take care of this, automatic tripping is indicated to the operator by blinking of the control lamp and by the ringing of a bell.

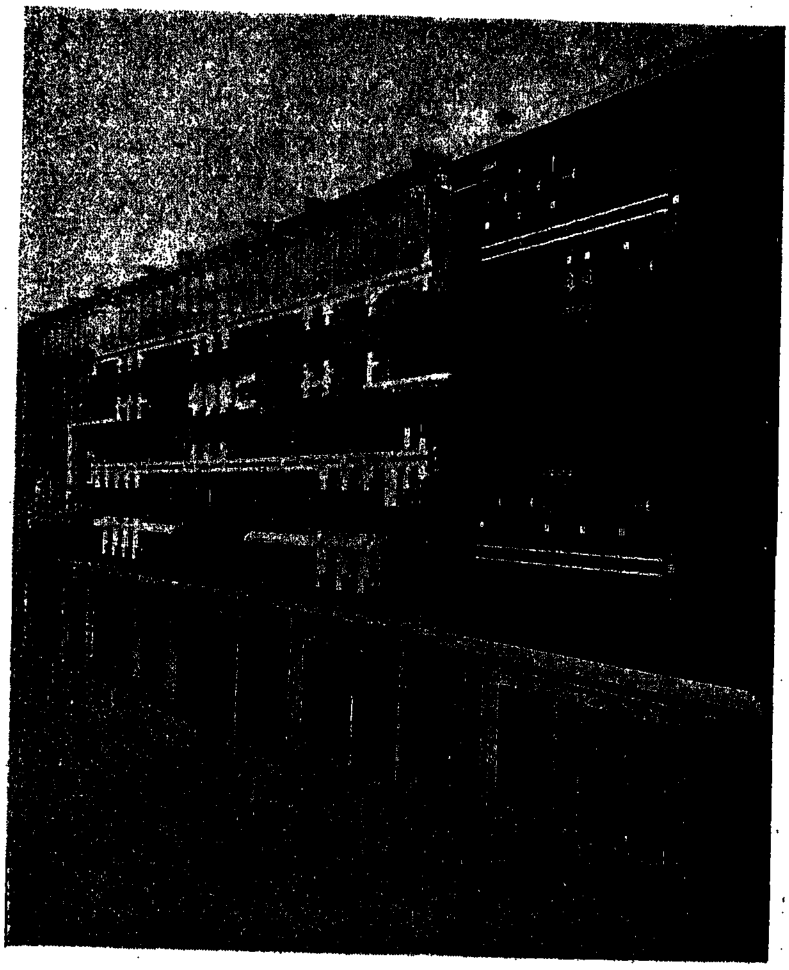

Fig. 3. Rear view of partially assembled luminous switchboard

Analogous circuits can be provided for other control and supervision operations such as the reading of meter indications, automatic position indication of manually operated disconnecting switches, alarm indications to warn of excessive temperatures, or other disturbances in the substation. The system can be modified easily to meet local conditions, and a single selector in the controlling station can be used for controlling several selectors in outlying stations.

Control switches, selectors, control lamps, and the various relays, can be mounted in different ways on switchboards or control desks. A suggested disposition applicable both to manual and to supervisory control which enables the operator to visualize at all times the condition of the system which he is controlling, is described as follows: The control switches are installed on a switch desk in front of the switchboard the handles of the switches forming part of a set of dummy buses so that the positions of all circuit breakers can be visualized. The switchboard is built from sheets of glass covered by an opaque paint leaving transparencies which form a diagram of the buses and lines duplicating the dummy set of buses on the switch desk. Indicating lamps are disposed behind the switchboard so as to show in proper colors the positions of the circuit breakers. Additional indicating lamps indicate whether or not the buses and lines are energized, for which purpose they are controlled by suitable relays connected to the circuit breaker controlling circuits. Additional transparencies provided in the lines can be used for indicating the readings of ammeters, voltmeters, or other instruments. Each of these transparencies discloses a meter box having a ground glass front graduated so as to provide a scale on which the readings are given by the shadow of the moving element of one or of several instruments. In this manner each meter is so located that it is immediately apparent to which circuit the reading refers. (See Figs. 3 and 4.)

This method of enabling the operator to visualize at a glance the condition of the network and the changes occurring therein, the position of the switching equipment, and the location of meter reading, greatly facilitates the supervisory operations and reduces the chances of performing wrong operations. In addition, the equipment is of a type with which the operators and maintenance crews are familiar, so that no special training is required for the personnel. These two advantages together with the flexibility and reliability of the equipment should make this system of particular interest to operating engineers.

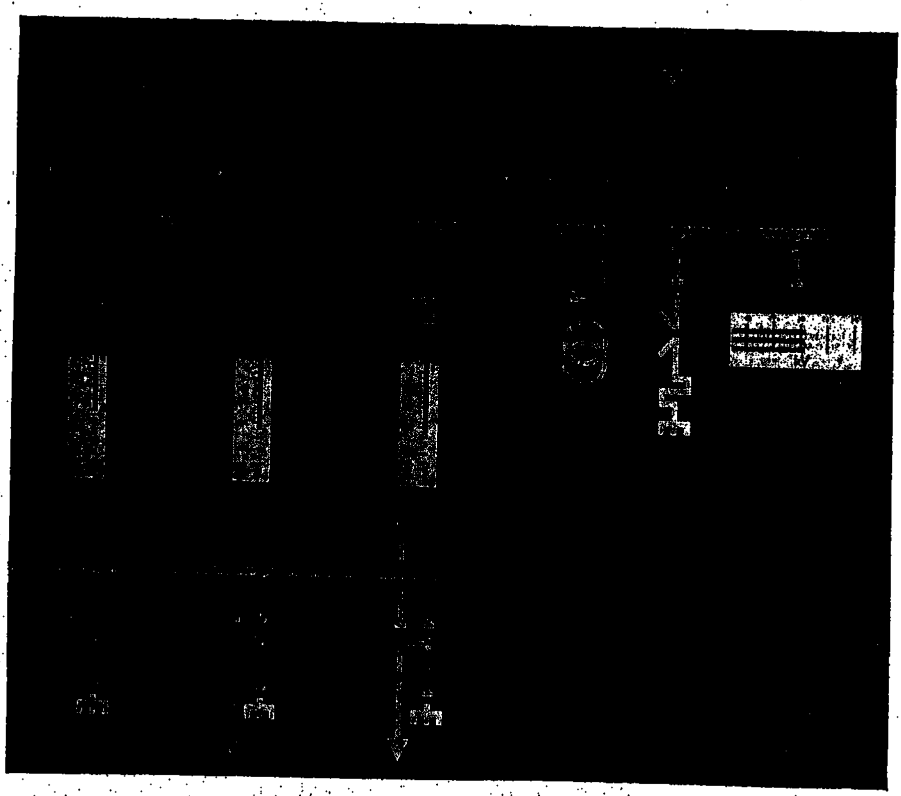

Fig. 4. Front view of a section of luminous switchboard with three feeder ammeters and bus voltmeter

# A New Carrier Telephone Cable

**Three carrier telephone circuits and one telegraph circuit are provided by this newest cable linking the United States with Cuba. The design is such that still more carrier channels may be provided when the need for them arises.**

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COMMUNICATION has advanced in many respects during the past decade. In carrier current communication over submarine cables this advance has been such that three telephone circuits are provided over the new Key West-Havana cable where each of the three earlier cables, installed ten years ago, provide only one. Furthermore, the new cable is but little larger than the three previously installed. ("Key West-Havana Submarine Telephone Cable System," A.I.E.E. TRANS., v. 41, 1922, p. 1–19.) This latest cable was placed in service in January 1931, and like the three cables just mentioned is owned by the Cuban-American Telephone and Telegraph Company, an organization controlled jointly by the American Telephone and Telegraph Company and the Cuban Telephone Company, and providing telephone facilities between the United States and Cuba.

The new cable, which has been designated the 1930 cable is the longest deep sea telephone cable in existence; also it is unique in being the longest telephone cable circuit without intermediate repeaters and without inductive loading. It is about 3.7 nautical miles (1 nautical mile = 6,087 ft.) longer than the longest of the 1921 cables. The design of the cable is such as to satisfy economically the need for more circuits by an adaptation of standard carrier apparatus. The design was made sufficiently liberal, however, so that certain further development work would make it possible to obtain over the same cable still more facilities when these are required.

a transmission standpoint, the feature of most interest is the unusually low receiving levels at which operation is carried on successfully. (See Fig. 1.) Of importance also is the fact that the new cable is operated over a far wider frequency range than are the older cables. Whereas the old cables are operated only up to 3,800 cycles per sec., the new cable at present is being operated at frequencies as high as 28,000 cycles per sec., and can operate at still higher frequencies.

## PARAGUTTA INSULATION USED

Paragutta insulation is the feature of the new cable which has enabled such great improvement to be attained. This material developed at the Bell Telephone Laboratories is composed of deproteinized rubber, deresinated balata, and wax. It has been described in detail by A. R. Kemp ("Paragutta, A New Insulating Material for Submarine Cables," *Jl. of the Franklin Inst.*, v. 211, Jan. 1931, p. 37). Heretofore submarine cables having waterproof insulation have almost invariably been insulated with gutta-percha or balata, or a mixture of these substances; an exception to this is the Catalina Island cables which are insulated with a special rubber mixture ("Carrier Current Communication on Submarine Cables," H. W. Hitchcock, A.I.E.E. TRANS., v. 45, 1926, p. 923–9). Paragutta has better electrical properties than any of these materials.

As shown by Table I, paragutta possesses a smaller dielectric constant and a smaller leakance than

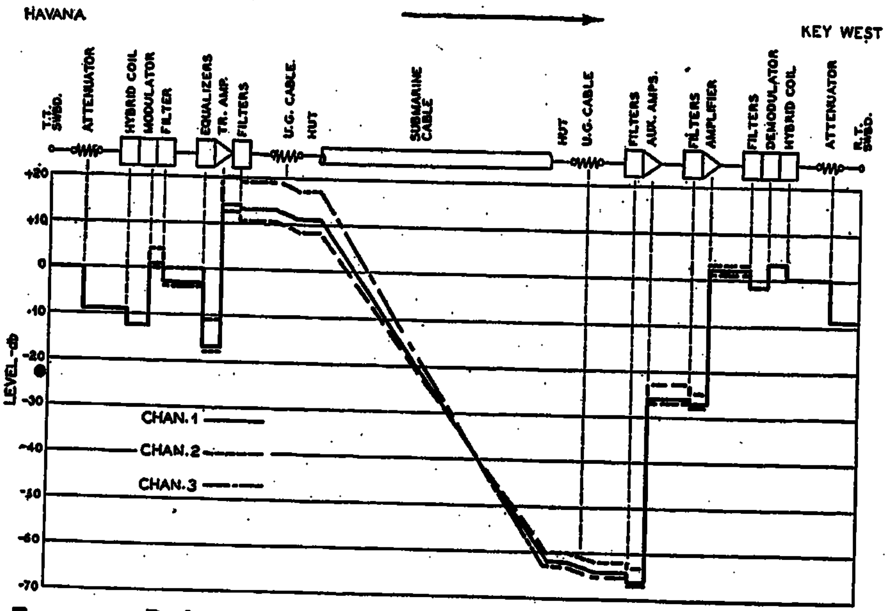

**Fig. 1. Relative transmission levels in 1930 Key West-Havana submarine telephone circuit**

Energy level at the toll switchboard on the left is taken as zero

**Table I—Comparative Properties of Gutta-Percha and Paragutta Insulations**

| | Diêlectric Constant | Ratio of Leakance to Capacitance |
|---|---|---|
| Gutta-percha (telegraph cable) | 3.3 | 4,040 |
| Gutta-percha as used in 1921 Key West-Havana Cables | 3.1 | — |
| Gutta-percha as used in Tenerife-Gran Canaria and Algeciras-Ceuta Telephone Cables* | 2.92 | 3,815 |
| Paragutta (Key West-Havana 1930 Cable) | 2.67 | 229 |

Measurements made at 22 kc. per sec. under sea bottom conditions.
*Electrical Communication, v. 9, 1931, p. 217.

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. New Key West-Havana Carrier Telephone Cable," presented at nter convention, New York, N. Y., Jan. 25–29, 1932.

gutta-percha. (The term leakance as used here includes all energy losses in the dielectric.) This property permits a considerable reduction in the size of a cable for a given attenuation. The decrease in size due to the use of paragutta varies of course with the size of the cable, but some idea of its amount may be obtained from the fact that a cable insulated with gutta-percha of the sort used in the 1921 cables would weigh 45 per cent more and cost about 65 per cent more than the new cable.

Use of this new material in the manufacture of a cable gave rise to numerous problems, one of which, namely that of jointing the paragutta, deserves particular mention. In this connection a new technique of jointing was developed which not only produces good joints in paragutta-insulated cable, but also produces better joints in gutta-percha-insulated cable than can be made by the conventional process which has been in general use since the latter were first manufactured.

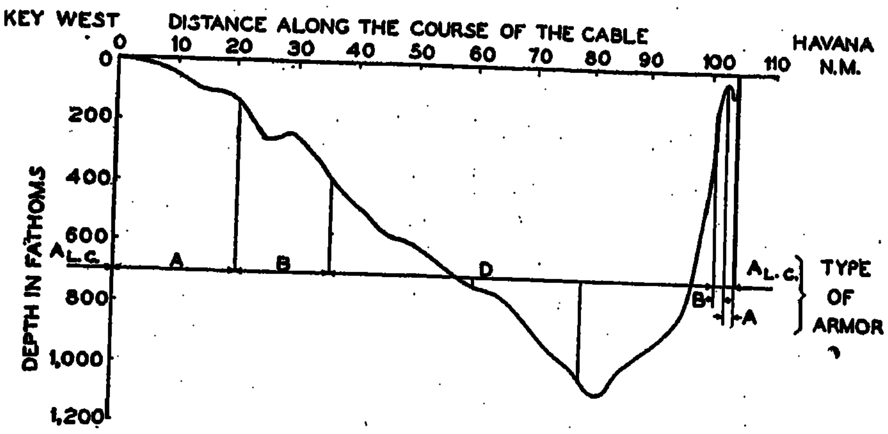
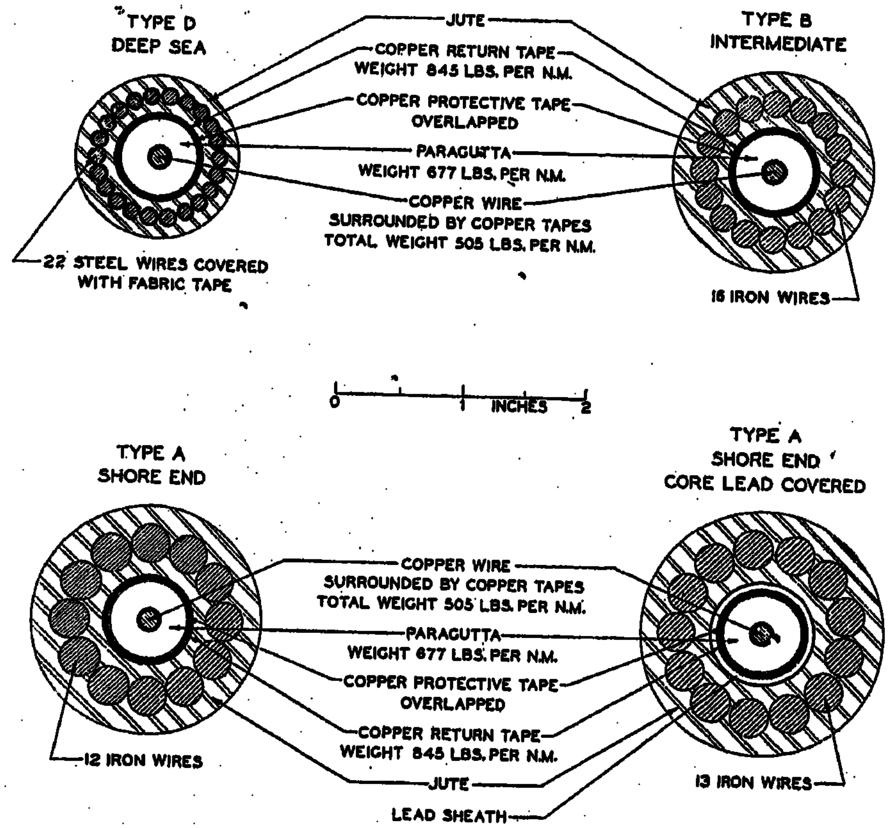


Fig. 2. Profile of route of 1930 cable; a fathom is equal to 6 ft.


TYPE D
DEEP SEA
TYPE B
INTERMEDIATE
JUTE
COPPER RETURN TAPE WEIGHT 845 LBS. PER N.M.
COPPER PROTECTIVE TAPE OVERLAPPED
PARAGUTTA WEIGHT 677 LBS. PER N.M.
COPPER WIRE SURROUNDED BY COPPER TAPES TOTAL WEIGHT 505 LBS. PER N.M.
22 STEEL WIRES COVERED WITH FABRIC TAPE
16 IRON WIRES
0
1
2
INCHES
TYPE A
SHORE END
TYPE A
SHORE END
CORE LEAD COVERED
COPPER WIRE SURROUNDED BY COPPER TAPES TOTAL WEIGHT 505 LBS. PER N.M.
PARAGUTTA WEIGHT 677 LBS. PER N.M.
COPPER PROTECTIVE TAPE OVERLAPPED
COPPER RETURN TAPE WEIGHT 845 LBS. PER N.M.
JUTE
LEAD SHEATH
12 IRON WIRES
13 IRON WIRES

NOTE:-THE WEIGHTS GIVEN ARE IN POUNDS PER NAUTICAL MILE=1.153 LAND MILES.

Fig. 3. Cross-sections of cables used at various depths (see Fig. 2)

## Cable Design

Except that it is not loaded, the new cable is similar in type to the 1921 cables. It is provided with copper return tapes ("Transmission Characteristics of the Submarine Cable," Carson and Gilbert, *Jl. of the Franklin Inst.*, v. 192, 1921, p. 705) and also with a thin copper tape under the return tapes for protection against marine organisms. The lay, or pitch, of the return tapes was made much longer ("U. S. Patent No. 1,700,476," Jan. 29, 1929) than in the 1921 cables. This brought about a substantial decrease in the effective resistance of the tapes themselves and reduced the eddy current losses which are due to the helical nature of the return tapes. Thickness of the insulation is much greater ("British Patent No. 343,093," May 7, 1931) compared with the diameter of the central conductor than is the case with low frequency cables, either telephone or telegraph.

In all matters of mechanical design, accepted cable practise was followed. A discussion of some of the mechanical features of cable design as well as some account of the general submarine cable problem has been given in the paper referred to in the first paragraph of this article.

Length of the new cable is 108.6 nautical miles (125.2 statute miles). It was manufactured by the Norddeutsche Seekabelwerke-A.G. of Nordenham, Germany, and laid by its cable steamer "Neptun." The maximum depth attained is 1,080 fathoms (6,480 ft.) as may be seen from Fig. 2. Cross-sections of the various types of cable used at different depths are shown in Fig. 3.

At carrier frequencies the effect of the armor wire is negligible from the standpoints of magnetic modulation and attenuation. Attenuation of the cable (see Fig. 4) is characteristic of a non-loaded cable in that it increases rapidly at low frequencies but less rapidly at high frequencies whereas in general the reverse is true of the loaded cable. Against electrical interference, but little shielding is needed beyond that furnished naturally by the sea water; the small additional shielding required is furnished by a wrought iron pipe enclosing the cable between the cable hut and the level of the lowest tides.

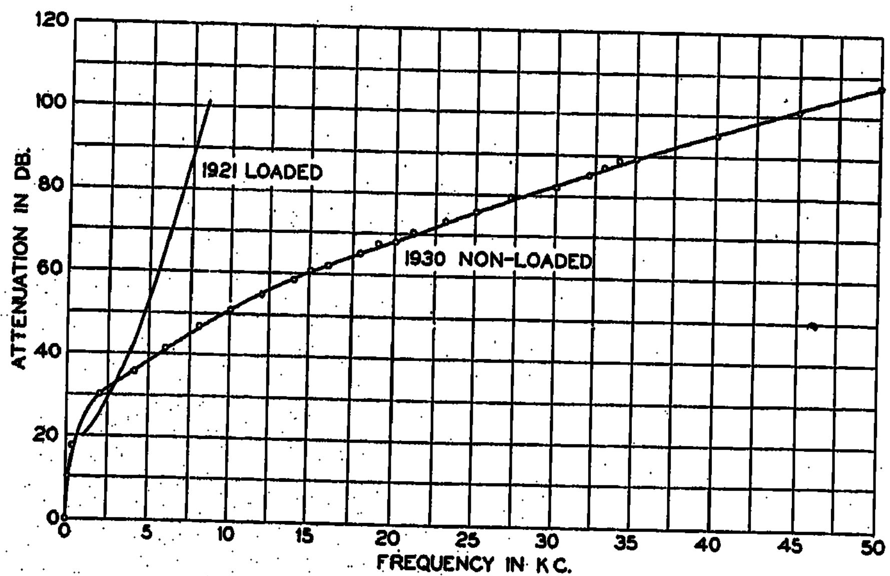


Fig. 4. Frequency-attenuation characteristics of 1921 and 1930 cables

## CARRIER SYSTEM

As noted previously, the three present telephone channels are obtained by an adaptation of carrier apparatus ordinarily used for long distance transmission over open-wire lines ("Carrier Systems on Long Distance Telephone Lines," Affel, Demarest, and Green, A.I.E.E. TRANS., v. 47, 1928, p. 1360-86). Special additional equipment consisting chiefly of receiving amplifiers and directional filters was added to care for the greater gain and selectivity needed to operate over the higher attenuation.

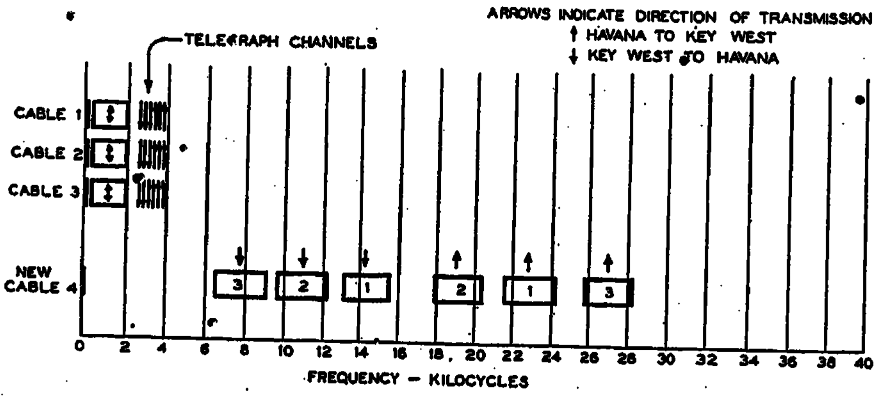


Fig. 5. Frequency allocation of communication channels in Key West-Havana cables

The six frequency bands (one for each direction for the three channels) are allocated as shown in Fig. 5; a d-c. telegraph channel also is indicated. This chart likewise shows the frequency allocation of the one telephone and four telegraph channels (three carrier and one d-c.) now carried over each of the three older cables. It may be noted that the frequency band width of the new telephone channels is much greater than that of the old ones, thus furnishing higher quality speech transmission. In addition, a large range of frequencies remains unused on the new cable; this range may be developed when additional message telephone, broadcasting, or telegraph facilities are needed.

Carrier apparatus is installed in existing telephone offices at Key West and Havana. In each case the office is somewhat over one mile from the cable but at the water's edge. The submarine cable circuit is connected to the apparatus in the offices through pairs of wire in an underground cable of the paper-insulated lead-covered type, which carries also the circuits of the older cables. In Fig. 6 is shown schematically the connections of the apparatus at the Havana end of the cable. The arrangements are practically identical at the two terminals except for differences incident to the fact that different frequency bands are transmitted in the opposite directions.

## SOME TRANSMISSION PROBLEMS

Satisfactory transmission over high cable attenuation involves several especially critical points. First of all, the transmitting amplifier must amplify to the high levels required without modulating sufficiently to produce troublesome new frequencies falling within its own group of frequency bands. New frequencies produced by the amplifier which fall outside of this group are suppressed by directional filters and cause no trouble.

Additional possible sources of modulation are the directional filters and impedance matching transformers; these must transmit the high levels coming from the amplifier but must not modulate them sufficiently to produce troublesome new frequencies falling within the oppositely directed group of bands. The latter are at an exceedingly low level and so the modulation in these circuit elements must be kept extremely small. Some ordinary resistances, mica condensers, and other apparatus,

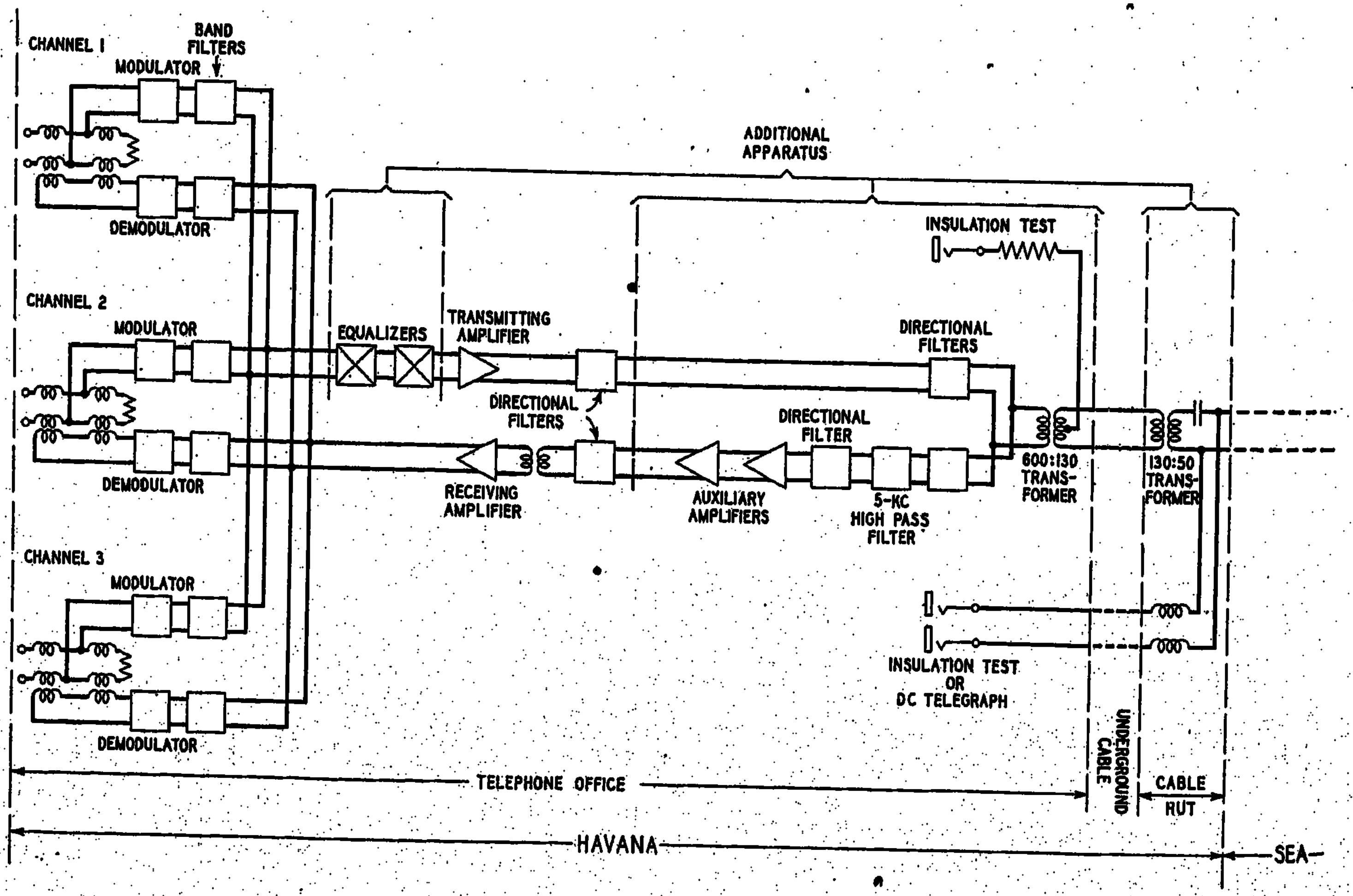


Fig. 6. Schematic diagram of carrier system used on the Havana end of the 1930 cable. Apparatus used on the Key West end is similar except of course it is designed for different frequencies

have been found to have enough modulation to be serious. In this respect ordinary iron core transformers are likely to be extremely troublesome; hence, special design is required to reduce the modulation in the impedance matching transformers to tolerable limits.

NOISE PREVENTION

At the cable ends the important problem naturally is to keep the low level receiving circuit free from interference. In taking the necessary precautions along these lines, many sources of noise were investigated and remedial measures provided. These included cross-talk from other carrier telephone or telegraph systems, high frequency oscillations set up by d-c. telegraph apparatus in the vicinity, radio stations, power wires, submarine telegraph cables, and many minor sources.

Of particular interest was the case where the Commercial Cable Company's submarine telegraph circuits from Havana to New York, a communication facility of low inherent frequency range, interfered with the carrier channels having frequencies up to 28 kc. This interference was found to originate by induction in the underground cable at Havana through which both circuits passed. In this case, by the generous cooperation of the Commercial Cable Company, frequency limiting equipment was added to its cable transmitter.

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# Electrical Units and Their Application

**Progress and improvement in any art or science are not made without provision for suitable measurements. Many advances in the field of electrical units and their measurements have been scored within the past forty or fifty years. Developments in electrical measurements have been satisfactory in that they have kept slightly ahead of practical demands.**

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ELECTRICAL UNITS are based upon or definitely related to units of length, mass, and time. In an ordinary sense the latter are not electrical, but because so much depends upon them it is of interest to know how definite and permanent they are; also how precisely they may be determined by reference to existing standards. Of interest also is the accuracy with which copies of the fundamental units may be made, and the degree of precision obtainable in producing for practical use multiples or submultiples of the fundamental unit chosen.

For ordinary work, accuracy of standard and precision of comparison considerably below the best obtainable are satisfactory. Workers in the field of primary reference standards, however, must be able to make determinations from 10 to 100 times more precise than those demanded in practise, so that the practical art has something to grow up to. Nevertheless, unusual practical requirements sometimes arise suddenly that can be met only with precision far greater than any previously employed. It is in this region of high precision that the national laboratories and some independent workers find a highly useful field; and in this class of work the U.S. Bureau of Standards ranks second to none.

For the fundamental units of length, mass, and time, perhaps the most familiar is the so-called c.g.s. system. In this system the centimeter is taken as the unit of length, the gram as the unit of mass, and the second as the unit of time. These units have been quite generally accepted for many years, and are likely to endure for some time to come.

FUNDAMENTAL C.G.S. UNITS

Mass standards are permanent and can be compared with a precision of one, or at least a very few parts in 100,000,000; standards of length are about the same. These therefore lie definitely in the $10^{-8}$ class. (A precision of from 1 to a possible 9 parts in 100,000,000 will be called $10^{-8}$, and so on down to $10^{-2}$.) Time, one of the fundamental elements in many things, hardly can be regarded as in the same class as length and mass. A minimum departure of about 0.001 sec. per day from a uniform rate is required in order that a clock may be included in the $10^{-8}$ class. This is better than has been attained over an extended period of time. The present status of time measurements places it in the $10^{-7}$ class; in fact it even has a tendency to slip into the $10^{-6}$ class.

Roughly 500 years ago the first instruments that really could be called clocks were brought out and were quite definitely in the $10^{-2}$ class, although probably the lower end of this band; in 300 years clocks were brought into the $10^{-6}$ class; and in about 150 years more, into the $10^{-7}$ class. During the

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Based upon "Electrical Units and Their Application" (No. 31-120) presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

* Deceased (Nov. 3, 1931).

last few years the clocks of Shortt and of Schuler, each quite different from the other, have given unmistakable signs of being able to qualify for the $10^{-8}$ class. This shows remarkable progress, for twice within about the last 40 years the error in timekeepers has been divided by 10.

This brief consideration of time is not really a digression, for within the last few years the demand for accurate measurement of time on which frequency or wave-length measurements are based came almost too soon. This is a definite example of the precision desired in practical measurements coming too close for comfort to the precision maintainable in primary reference standards.

The time measurement situation, however, is not without its brighter side. The crystal oscillator, which in a certain way caused the trouble by requiring accurate adjustment and timing, has been found to be itself a most reliable timing device. First checked with clocks, it now bids fair to turn about and enter the higher timekeeping class itself. Comparisons between crystal oscillators now can be placed in the $10^{-8}$ class, and timing of crystals in the $10^{-7}$ class.

This brief discussion is of interest because it indicates the present status of units and measurements of the three fundamental standards. The conclusion is that they are in a fairly satisfactory position with time far in the rear, but rapidly advancing to a position of equality with length and mass. Therefore these units form an excellent basis upon which a system of electrical units may be built. Difficulties are experienced, however, in the steps necessary to realize electrical standards from standards of length, mass, and time; no doubt improvements in methods and procedure will be made in time so that the precision assignable to the three fundamental units may be realized more nearly in the electrical units used for fundamental reference.

## ELECTRICAL UNITS

Of primary interest in the field of electrical units are the ohm, the volt, and the ampere, or the absolute units of which these are derived multiples. As may be seen later a wide gap exists between the precision assignable to length, mass, and even time, and that assignable to the absolute values of the practical electrical units. This is so for very good reasons: Fundamental length and mass standards are in a sense arbitrary; this does not give concern because when once established such standards remain permanent within satisfactory limits. In considering electrical units, however, their relation to length, mass, and time must be known; also electrical units must not be arbitrary if agreement with mechanical and other units derived from length, mass, and time is to be maintained. Electrical standards therefore must be kept from change and at the same time must be brought into a definite and predetermined relation to the fundamental units, so that conversion factors may be as simple as possible.

The ohm now is defined as the resistance at 0 deg. cent. of a column of mercury approximately 106.30 cm. in height and having a cross-section of 1 sq. cm. The value of the ohm may be certain to five significant figures ($10^{-4}$) but can hardly be said to be known dependably to six figures ($10^{-5}$). However, work is being done constantly to better this situation. In general, copies and comparisons of resistances may be made to a precision of about $10^{-6}$ with a permanence of primary reference standards of about the same order.

On the basis of the foregoing, the ohm may be considered to be in a fairly satisfactory state of determination, but more certainty as to its absolute value is desirable (at least to a precision of $10^{-6}$). Gratifying progress in this direction has been made. Looking back to the first ohm established by the British Association committee, this unit was about 1.5 per cent smaller than the present ohm. It has taken nearly 50 years to eliminate the greater part of this error, although most of the change was made in one important step. Precision and permanence of the ohm have just about kept out of the way of progress in the practical field.

The volt had a rather bad start; in the early days it was derived primarily from the ampere and the ohm. With much time and care, galvanometers were constructed depending for their accuracy upon measurements of length, and upon the strength of the earth's magnetic field. Here again the unit was tied up with a property of the earth as is the present unit with time; unfortunately, however, amperes cannot be transmitted by telegraphic signal or radio, and although the earth's magnetic field is capable of precise determination, the ampere or multiple of it when realized could not very well be carried home and used. Instruments then were made which did not involve a permanent magnet and which did not depend upon the earth's magnetic field. Some of these electrodynamometers were very good, but were not always dependable or precise within the required limits.

## WESTON CELL AN IMPORTANT ADVANCE

No competitor of the galvanometer or electrodynamometer appeared until the advent of the Clark cell, although certain voltaic cells had been known for some time. The Clark cell could be reproduced in various localities with considerable precision. However, this cell had a marked temperature error, and also was fraught with other difficulties which prevented its general use. The situation regarding the volt was improved enormously, however, when Edward Weston introduced his Standard cell. It was this cell which, in one form or another, now is used, together with copies of the ohm or multiples of either or both, as the basic standard of most electrical measurements. The present status of the volt is such that it is practically in the same class as the ohm, that is the $10^{-4}$ class; as a result the ampere in terms of these two standards may lie perhaps in the same class. This refers to absolute values only; comparisons probably are possible to a precision of about $10^{-6}$.

Using standard cells and carefully compared resistances, a class of instruments has been developed for the determination or realization of ohms, volts, amperes, and watts. These commonly are known as bridges and potentiometers and are capable of giving multiples of the units over a wide range with a precision well up into the $10^{-5}$ class. These instruments are convenient to use and are permanent and reliable; they are employed primarily for the calibration of portable and working instruments. For these purposes, however, the precision of which they are capable is unnecessarily high. Still another class of instruments is represented by the deflection potentiometer, which falls perhaps in the middle part of the $10^{-4}$ class as regards precision.

These instruments may be used both as reference standards and for direct observations. As a result, for continuous currents it is possible at any time to secure definite and accurate measurements which in most cases excel the practical requirements in this respect.

## A-C. MEASUREMENTS

Many measurements must be made where alternating current is the medium; here, in special cases, the instrument commonly used employs some sort of a reflecting device for observing the indications of the moving part. As regards precision these instruments may be placed on the borderline between the $10^{-3}$ and $10^{-4}$ class, but they do not fill the requirements of this class with complete success.

Considering the instruments available for the intermediate class of work (between $10^{-6}$ and $10^{-8}$) of which so much must be done, time and patience surely are taxed to obtain the required results. For this type of work, instruments similar to the deflection potentiometer which would be conveniently usable on alternating current, would be extremely helpful. Another factor which must be considered in this regard is the step from d-c. to a-c. measurements which rests upon the assumption that for the same r.m.s. values, a given instrument will give the same indication on alternating current as it does on direct current. This step does not in all cases rest upon a perfectly secure basis.

## USE OF PORTABLE A-C. INSTRUMENTS

In using portable direct-reading instruments or instruments of the intermediate class on a-c. circuits or systems, it is difficult sometimes to realize the precision of which the instruments are capable. This is because of slow pulsations in the supply source and because all moving systems have not the same time of swing. In addition, a-c. measurements of necessity involve work on rotating machinery and this fact introduces more problems. Some success has been attained by recording photographically or by other means the positions of the pointers of a group of instruments, but this is not always satisfactory; it is usually best to record enough readings to overcome the effects of fluctuations. Although in a well equipped laboratory matters can be improved greatly by using refined regulators on the supply lines, this fills but a small part of the general need.

In dealing with large values of a-c. amperes, volts, and watts, usually it is not possible to employ resistances so precisely comparable with reference standards. In this field it has become customary to employ instrument transformers. These transformers are capable of quite precise work, and when carefully checked and properly used, may be placed in the lower part of the $10^{-4}$ class. Instrument transformers serve the purpose also of protecting the observer from contact with the circuit voltage.

Within comparatively recent years the electrical measurement art has required expansion into the high frequency field and also into the field of very low power-factor measurements; here new requirements are met involving many curious effects which must be guarded against. The recording of wave fronts expressed in microseconds, together with a great variety of problems connected with sound and communication systems using wires and with the radio art, have been met for the most part with a fair degree of satisfaction. This general group cannot be referred to in detail; a tremendous range of voltage, current, power, and frequency must be covered from comparatively small values up to millions of volts, thousands of amperes, and millions of cycles per second.

## OTHER DEVELOPMENTS

Great increases in sensitivity and decreases in the amount of power required to make measurements have been made possible by the use of vacuum tubes; hence a large expansion in this field may be looked for. Permanence and reliability if they could be increased would enhance the usefulness of these methods.

Capacitors or condensers are very useful devices for, when charged with a voltage which can be determined very precisely from standard cells and suitable multiplying arrangements, they are able to give out a definite quantity of electricity. However, condensers are not permanent and reliable to the same extent as resistors and standard cells, and improvements along this line would be desirable. For example, in magnetic measurements it would be much simpler to work from a reference standard condenser than to use mutual inductances determined by some of the well-known methods of comparison, or by direct reference to length standards.

Materials for resistance standards have been improved greatly and at present there appears to be but little need for further improvement. Accuracy with which comparisons can be made is perhaps ten times greater than the precision or permanence of resistance units assembled in practical apparatus without taking undue precautions; such precautions need not be taken if the temperature effects were less than they are now.

Increased development of instruments in the intermediate class ($10^{-4}$) is hoped for; devices are needed which will stand in the a-c. field (at normal and if possible at high frequencies and at low power factor) in the same place that the deflection potentiometer, resistances, and standard cells occupy with respect to d-c. applications.

Among practical workers but little advance has been made along the line of combining and weighing of results, and in the application of well-known and simple probability relations. It is possible to do much along this line; a few simple relations would cover most cases and would be of enormous advantage. Experience can develop an intuitive sense in this regard and if the results obtained with a number of determinations are made use of, and sufficient care taken to control the conditions under which the observations are made, it is surprising what can be done with comparatively crude apparatus.

## SUMMARY

It is not intended that the conclusion to be drawn from this brief review is that conditions regarding electrical units are unsatisfactory. Of course the point of view might be taken that satisfactory progress has not been made in the last 50 years and that the best reference standards are not at all in the same class with available standards of length, mass, and time. Ordinary portable electrical instruments seem crude in comparison with portable and every day instruments for determining mass, length, and time; but the situation should not be regarded at all in this light. Length, mass, and time standards have had at least ten times as long a period of development as have electrical standards.

The one fundamental unit that has advanced the most is time; this advance has been about 100 fold in the past 40 years. Electrical reference standards and the precision of comparison with such standards have been advanced in relation to the fundamental units, by about the same amount in the same length of time. In the portable instrument field and in indicating instruments generally, errors have been divided by about 10 within the same period. Therefore, the situation may be reviewed with some degree of satisfaction. Progress in the field of electrical units has equaled by comparison the rate of progress in other branches, but there is still much to be done and much to be learned by occasional excursions into other lines a little outside of the electrical field. Most important of all, the interest in going forward assuredly is undiminished, and during the next few years further and important advances will be made.

# The Unit of Electrical Resistance

**The mercury ohm, long recognized as a standard of resistance, with its elaborate technique and many disadvantages has become obsolescent. The reasons for this, together with a brief historical sketch of the ohm, are presented in this article.**

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IN SPITE OF the vast amount of high class technical labor which has been expended upon the mercury ohm it seems physically impossible to push its limit of reproducibility beyond that attained thirty years ago, namely, a few parts in 100,000. On the other hand, the technique of absolute measurements has improved continuously, until now it is at least on a par with the mercury ohm as regards reproducibility. The technique of absolute measurements undoubtedly can be improved; but even if no better than the present parity (as to reproducibility) with the mercury ohm were maintained, the latter, always a necessary evil, has no further reason for existence. Recognizing these facts the advisory committee on electricity of the International Committee of Weights and Measures, at its 1930 meeting held in Paris, adopted the following resolution:

> "With regard to the unit of resistance, the ohm, considering that methods of determining the absolute ohm are sufficiently advanced and that the agreement between the measurement of the coils (secondary standards) of the different (national) laboratories remains within the limits of precision of the measurements, it is not necessary at present to undertake further comparisons of the resistance coils with mercury ohms."

In order to bring out the full significance of this seemingly radical proposal and the sound reasons for the ultimate abandonment of the mercury ohm as a legalized material standard, a brief historical review of the ohm may be of interest.

## EARLY WIRE STANDARDS

After the announcement by Ohm in 1827 of his famous law, electrical workers began to feel the need for a unit of electrical resistance. As a result several arbitrary standards were suggested by different scientists, these consisting mostly of specified lengths of certain kinds of metallic wire. All of these early proposals, however, were faulty; simple metals were difficult to obtain in sufficient purity, and their resistivity was affected by internal stresses and by the degree of annealing. In addition the alloy wires advocated by some were not of definite or exactly reproducible composition.

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Based upon "The Unit of Electrical Resistance: Past History and Impending Change" (No. 31-110) presented at the A.I.E.E. summer convention, Asheville, N. C., June 22-26, 1931.

Use of mercury as an ideal metal for an electrical resistance standard seems to have been suggested first by Marie-Davy, but in 1860 Werner Siemens made the first practical proposal concerning it, namely, that the unit of resistance should be "the resistance at 0 deg. cent. of a prism of mercury 1 m. long and 1 sq. mm. in cross-section." He demonstrated that he could reproduce a unit of resistance by means of mercury in glass tubes with an error of less than 5 parts in 10,000. The unit he proposed came into use under the name *Siemens Einheit* (Siemens unit) denoted in the older literature by the abbreviation *S.E.*

In 1861 at the suggestion of Sir William Thomson (later Lord Kelvin) the British Association for the Advancement of Science appointed a committee on standards of electrical resistance. This "B.A." committee as it was known, recognized the necessity for material standards of resistance, but also desired that such standards refer ultimately to an absolute basis; such a material standard when once established was to be regarded as a prototype standard and never to be changed even though succeeding absolute measurements might show it to be appreciably in error. As the absolute basis upon which to establish the proposed standard, the committee finally adopted the centimeter-gram-second, or ordinary c.g.s. system.

### B.A. UNIT ESTABLISHED

Three members of the B.A. committee in 1863 and 1864 made absolute measurements of resistance at King's College, by rotating a short-circuited coil of copper wire about a vertical diameter and with a measured velocity, observing the resulting deflection of a magnetic needle at the center of the coil. From the known angular velocity, the deflection of the magnet, and the linear measurements of the coil, the resistance of the coil was computed in absolute units. Upon the basis of this work, the committee constructed standard coils of platinum-silver wire, and began to issue copies of the "B.A. Unit." The committee was dissolved in 1870, but in 1878 the investigations of Rowland at Baltimore showed that the B.A. unit was more than 1 per cent smaller than the value ($10^9$ c.g.s. electromagnetic units) which the committee had intended to give it. This result was verified soon afterward by other investigators, and in 1880 the B.A. committee was reappointed.

In the meantime several mercury standards of resistance had been set up in accordance with the proposal of Werner Siemens. From the standpoint of that time, agreement between these standards was satisfactory and the results of absolute determinations consequently had been referred directly or indirectly to the Siemens Unit.

### EARLY ATTEMPTS TO LEGALIZE THE MERCURY OHM

In 1881 an International Congress of Electricians met at Paris for the purpose of establishing definitions of the electrical units in a form suitable for enactment into legislation. This congress adopted a resolution proposing: that the ohm preserve its previous definition, namely, $10^9$ c.g.s. electromagnetic units; that it be represented by a column of mercury 1 sq. mm. in cross-section, at a temperature of 0 deg. cent.; and that an international commission be charged with the determination, by new experiments, of the length of the mercury column to have a resistance of $10^9$ c.g.s. electromagnetic units. At its second meeting, held at Paris in 1884, this commission known as the International Conference for the Determination of the Electrical Units, adopted 106 cm. as the length of the mercury column, in spite of the fact that the best absolute determinations indicated 106.3 cm. to be more nearly correct. This compromise with the facts was made because it was considered advisable for a provisional value to be correct to the last figure given. The unit of resistance so defined was given the misleading name *legal ohm*, but although it was used to some extent, it was never legalized.

The B.A. committee mentioned previously continued its work during the next succeeding few years, adopting the legal ohm in its standardizing work with a supplementary statement of the value of the legal ohm in B.A. units. In 1892, however, this committee discontinued issuing standards in terms of the legal ohm in favor of the ohm defined as a resistance of a column of mercury 106.3 cm. long. In the meantime this committee had experienced difficulties from variations in the relative values of its wire standards. These difficulties effectually negatived the committee's original plan for a wire standard never to be altered, and established the fact that some independent and reliable method for checking the constancy of the wire standards was required.

### MERCURY OHM ADOPTED INTERNATIONALLY

Another important development came about during the Chicago Exposition of 1893, when an international electrical congress met with representatives of ten governments in attendance. This congress adopted resolutions defining eight electrical units, and to distinguish them from their predecessors these units were called *international* units. The international ohm was defined as being based upon $10^9$ c.g.s. units of resistance, and as represented by the resistance offered to an unvarying electric current by a column of mercury 14.4521 g. in mass at the temperature of melting ice, having a length of 106.3 cm. and a constant cross-sectional area.

Because of certain defects and inconsistencies in the resolutions of the Chicago congress, the six national governments which afterward legislated on the matter defined the electrical units in different ways. One of the outstanding defects of the Chicago resolutions was that the ohm, ampere, and volt, which are physically related by Ohm's law, all were defined in terms of material standards.

The next international congress on electrical units and standards was held in 1908 at London, with delegates from 21 countries. At this meeting resolutions were adopted which for the first time clearly differentiated between the fundamental (absolute) electrical units, and a system of units representing the fundamental units, and sufficiently near them for practical use and to serve as a basis for legislation. Recommendations made by this conference, however, did not affect the value of the ohm; hence the international unit of resistance remained as defined at the Chicago exposition congress of 1893, and has not been altered since that time.

Time and patience required in making mercury ohm determinations are so great, however, that in spite of its legal standing, only a relatively small number of outstanding determinations have been made during the past thirty years. The elaborate technique of cleaning, calibrating, and cutting off the tubes, measuring their length, determining the mass of contained mercury, and of comparing the resistances of the tubes with existing wire standards, is too laborious and involved to be outlined here. To be worth doing at all, this technique must be carried out by scientific men of great manipulative ability, with the observance of extreme precautions against errors in various parts of the measurement.

## Advantages and Disadvantages of Mercury Ohm

Principal advantages of the mercury-ohm standard are as follows: The conducting material is free from internal molecular stresses and is purifiable to a high degree. Because it can be reproduced from specifications, the mercury-ohm standard serves to record the unit of resistance of any given period within a few parts in 100,000 for future reference. The standard is simple in construction, but for many years its numerous drawbacks have caused it to be much neglected, even in countries which have legalized it.

Disadvantages of the mercury-ohm standard are: The conducting material has a high temperature coefficient of resistance, which in conjunction with the high thermal resistivity of glass makes it difficult to measure the temperature of the mercury with sufficient exactness and limits the allowable test current through the mercury column to a small value. It is known now that mercury is not a simple substance, but a mixture of isotopes. (This is not a serious objection from the practical standpoint, because the particular mixture of isotopes of mercury found in nature seems to be very closely the same everywhere.) The mercury is liable to slight contamination from the metal electrodes immersed in it. Glass tubes cannot be made straight and of uniform bore, and the error arising from waviness of the bore, though of known sign, is of indeterminable magnitude. Terminal bulbs which are necessary to make connection to the ends of the mercury column introduce an uncertainty because as yet no method has been found for definitely calculating the terminal resistance with sufficient accuracy; this makes it necessary to adopt an empirically chosen size of end bulb. The wires which lead the current into the terminal bulbs must be small so as to minimize the conduction of heat to the mercury; they are therefore of relatively high resistance, which is a drawback in some methods of effecting electrical comparisons.

It may be of interest to summarize some of the other major reasons for the original adoption of the mercury ohm and its present obsolescence. The mercury ohm originally was proposed at a time when electrical workers were isolated. Existing means of communication were slow and imperfect, and hence each worker felt the need of preparing his own standards. Although the underlying absolute electrical units were recognized from the beginning of the B.A. committee's work, the crudities of apparatus and technique of absolute measurements resulted in such a scattering of values obtained, as to constitute an imperative reason for a physical standard of resistance reproducible from specifications.

The situation has altered greatly since the beginning of the present century. The day of the isolated worker, setting up his own standards, has passed, and now great national standardizing laboratories not only establish standards with an accuracy beyond the resources of most individual workers, but have a legal status which gives the stamp of authority to their certified values. By the exchange of standards, these national laboratories keep in touch with one another, thus securing a measure of international uniformity.

## Absolute Measurements

It is beyond the scope of this article to give more than the briefest reference to absolute measurements. The spinning coil of the B.A. committee already has been mentioned. The Lorenz apparatus is an elementary dynamo in which a non-magnetic metallic disk is rotated within the magnetic field of two solenoids wound on non-magnetic cores and traversed by a steady direct current from an external source. The apparatus thus constitutes a sort of homopolar generator in which an e.m.f. is induced radially in the rotating disk. At a certain definite speed, this induced e.m.f. will just balance the *IR* drop between the potential terminals of a four-terminal resistance standard through which passes the steady current circulating in the solenoids. From the accurately determined speed of rotation, and from mechanical measurements of the dimensions of the disk and of the field coils, the resistance of the standard between its potential terminals can be calculated in terms of the c.g.s. absolute electromagnetic unit. The most outstanding Lorenz apparatus built thus far is that at the British National Physical Laboratory.

An absolute apparatus, simpler in some respects, is used at the German Reichsanstalt and at the United States Bureau of Standards. It employs single-layer solenoids wound upon accurately machined cylindrical forms of non-magnetic material such as marble. In terms of the fundamental units, the self-inductance of such a coil can be computed with high accuracy from measurements of its dimensions. The self-inductance also can be measured in terms of the international ohm and the second of time by means of a-c. methods, using currents of which the frequency is known accurately. From the two results may be derived the ratio of the international henry to the absolute henry ($10^9$ c.g.s. units of inductance). It may be shown that this ratio, which is 1.00052 plus or minus a few units in the last place, is also the ratio of the international ohm to the absolute ohm. Results obtained by this a-c. method are in close agreement with those obtained with the Lorenz apparatus.

### Legalized Standards Needed

It would be premature to attempt to set even an approximate date for the establishment of the absolute electrical units on a *legalized* basis, but there are urgent reasons for reaching this goal as soon as possible. Rapid development of electrical technology in recent years has imposed new and exacting demands for accuracy of measurement and permanency of standards. Nowhere is this demand more impressive than in some phases of the radio art where for example frequency measurements are carried out and standards of frequency have been developed to an accuracy so great (a few parts in ten million) as to threaten to expose the failings of even the most highly developed timekeepers used in observatories. The world-wide sweep of radio makes international uniformity of frequency standards an imperative necessity.

Electrical standards of various kinds, embodying errors known to exist in the present units, are being made and distributed more widely than ever. This is an added incentive toward legalization of absolute units, for the longer such action is deferred, the more costly and troublesome will be the necessary readjustment of the standards used in engineering and science when such legalization ultimately is accomplished.

# International Standard of Electromotive Force

**Although unremitting care must be exercised in their manufacture and handling, cadmium cells have proved to be convenient and reliable sources of standard e.m.f. Principal characteristics of these units and precautions to be observed in their use are pointed out in this article.**

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THE INTERNATIONAL VOLT is defined in terms of the mercury ohm and the silver voltameter. This combination, in addition to being unsuitable for routine work, requires that an unchanging potential drop be maintained across the standard ohm which in turn demands that a source of constant e.m.f. be available to maintain a constant current through the voltameter. Such a source of constant e.m.f. when so used undergoes calibration and thus may become useful as a standard of e.m.f. without combination with the voltameter and the ohm. If such sources are to serve as primary standards, for convenience they should be reproducible.

In practise, galvanic cells provide serviceable standard sources of e.m.f., and are known as *standard cells* when they fulfil the necessary requirements. Two general types of construction are to be had, namely, the portable form in which the constituents are kept in place by a plug or septum of porous material, and the non-portable type without a septum, gravity holding the constituents in place. Generally the container is a glass vessel made of tubing in the form of an H.

In addition to this purely physical distinction in standard cells, there is a more fundamental difference between *normal* or *saturated* cells and *unsaturated* cells. The normal cell contains an excess of the salt of the electrolyte, and it is reproducible at all temperatures within its range. The unsaturated cell has an electrolyte saturated at some temperature below the customary range of room temperatures. Therefore, due to difficulties of technique, the unsaturated cell is not reproducible. However, it is constant in e.m.f. and has a lower temperature coefficient than does the normal cell. Temperature coefficient of the unsaturated cell can be taken as less than −0.00001 volt per deg. cent.; hence, though the normal or saturated cell makes the best primary standard, the best laboratory standard is the unsaturated cell calibrated against the normal cell, the latter in turn having a value based upon the ohm and the voltameter.

### Weston Introduced Cadmium Cell in 1893

Although several different standard cell systems have been introduced, all except one now are of historic interest only. The specific system in general use today is that proposed by Dr. Edward Weston; its unsaturated form was patented by him in 1893, and consists of mercury-mercurous sulphate-aqueous solution of cadmium sulphate-cadmium amalgam. In his honor, the two types of this cell are known, respectively, as the normal Weston cell or the

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Based upon "International Standard of Electromotive Force and Its Low-Temperature-Coefficient Form" (No. 31-121) presented at the A.I.E.E. summer convention, Asheville, N. C., June 22–26, 1931.

saturated Weston cell, and as the unsaturated Weston cell or simply the Weston cell. These cells are known also as the cadmium cells, the terms cadmium cell and Weston cell being synonymous as applied to the composition of the system, but the latter requiring no further qualification to denote that it specifies an unsaturated element.

Materials used in cells require careful chemical treatment. Mercurous sulphate is particularly sensitive, but when mixed with finely divided mercury can be prepared by electrolysis; this is the best preparation found so far. Cadmium sulphate would seem to require more rigorous purification than it has received at the hands of many investigators in the past, more especially to eliminate salts of manganese. Mercury must be redistilled after washing in acid, and only the purest cadmium must be used.

### Use of Standard Cells

Since current should not be drawn from standard cells when making comparisons against such units, only a null-point or compensation method should be used; some form of potentiometer provides this. ("A Simple Direct-Reading Potentiometer for Standard Cell Comparisons," Eppley & Gray, *Jl. Opt. Soc. Am.*, v. 6, 1922, No. 8, p. 859–64, and "An Improved Fuessher Type Potentiometer," Eppley & Gray, *Rev. Sci. Inst.*, v. 2, 1931, No. 4, p. 242–9.) Usually the entire e.m.f. of the cell used as standard is compared against the entire e.m.f. of the cell being checked; in this method the potential drop in the potentiometer acts as a transfer-standard. This drop must be kept constant, so that it is well to lag the storage cell (which furnishes the potentiometer current) with heat-insulating material to prevent changes in room temperature from causing fluctuations in the measuring current, or potential drop. For best results, accumulators should be kept on a stand above the floor in order to avoid drafts. With this precaution, and by shifting from standard to unknown several times with readjustment of the measuring current if necessary and the attainment of a new balance with the unknown, results can be obtained with a potentiometer of proper design that will be reproducible from day to day within 6 microvolts. Furthermore, this method has the convenience of being direct-reading.

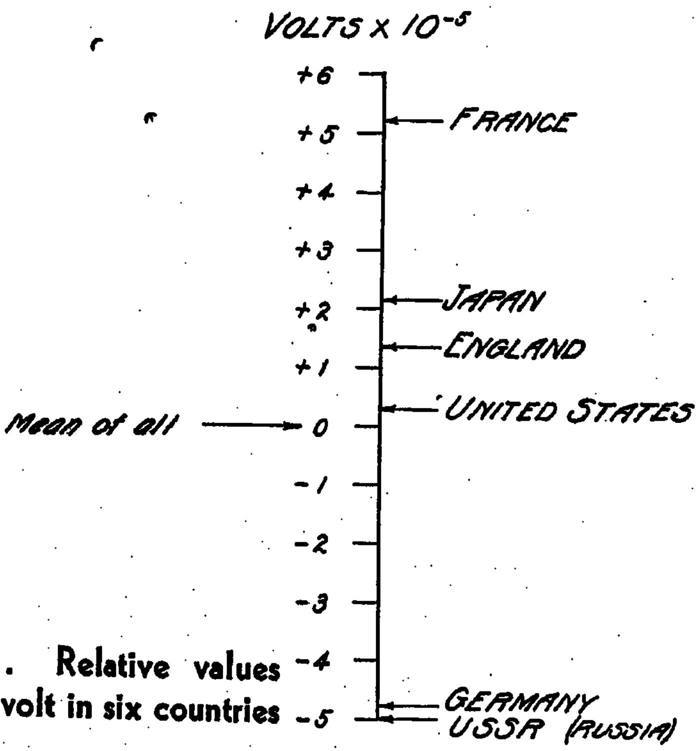

**Fig. 1. Relative values of the volt in six countries**

By Vinal, *Trans.* Am. Electrochemical Soc., 54, 251 (1928) Fig. 1

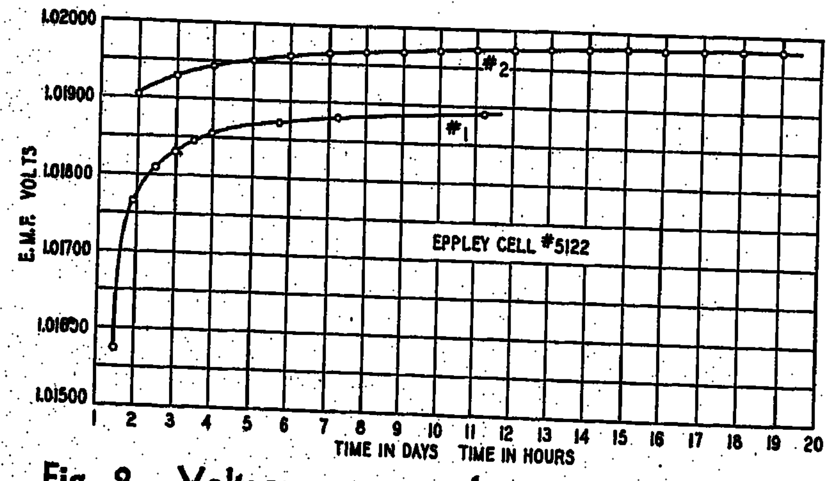

**Fig. 2. Voltage recovery of an unsaturated cadmium cell after 30-min. short circuit**

Curve 1—voltage vs. hours for first day
Curve 2—voltage vs. days from second day
Volts before short circuit—1.019875
Volts after 36 days' recovery—1.019800

One disadvantage of the method just described, though perhaps more theoretical than real, is that the standard and the unknown are not compared at the same instant. For measurements beyond criticism, therefore, it is best to oppose the unknown and the standard, reading the difference in e.m.f. on a potentiometer or by some other suitable means. This reduces to a minimum the effect of fluctuations in the measuring current, and makes use of only one or two dials of the potentiometer with a corresponding reduction in the number of corrections to be applied. This method is not direct-reading, however, and the sign of the residual must be watched carefully. Whatever method be used, the measuring current must be made such that it will have come to a steady state. Careful attention should be given also to shielding the installation against stray leakage currents.

### Voltage of the Weston Cell

Looking forward to its ultimate use as the international standard of e.m.f. in place of the Clark cell, the London International Electrical Congress in 1908 adopted specifications for the Weston normal cell provisionally fixing its e.m.f. at 1.0184 international volts at 20 deg. cent. On January 1, 1911, however, after much experimentation by the International Technical Committee (composed of delegates from the national standardizing laboratories of Great Britain, France, Germany, and the United States) the e.m.f. of the normal cadmium cell was adopted by the Bureau of Standards as 1.01830 volts at 20 deg. cent. for the United States. During the interval 1924 to 1928, the reference cell at the Bureau of Standards has agreed to within 8 microvolts with the mean of the primary reference group (a group of 36 cells left at the Bureau by delegates of the International Technical Committee). The value of e.m.f. at the Bureau of Standards is about 3 microvolts higher than the mean of the values of the cells maintained in France, Japan, England, the United States, Germany, and the U.S.S.R. (See Fig. 1.)

All cadmium cells show a temperature hysteresis of e.m.f.; although this can be made very small, it still exists. Hence cells should not be subjected to sudden changes of temperature. Cooling from 30 to 25 deg. cent. in 70 min. caused a divergence of 0.02 per cent in one group and 0.027 per cent in two groups of cells respectively, the basic value being the mean of the e.m.f.'s obtained before the cells were run through a temperature cycle from 15 to 50 deg. cent. and back to 25 deg. cent. as above.

Unsaturated or Weston cells show a drop in e.m.f. of about 0.003 per cent per annum, so that for an accuracy of 0.01 per cent they should be recertified at least once every two years. This drop is explained best by the diffusion of mercurous ions to the amalgam face where it is discharged, mercury depositing out and cadmium going into solution; this increases the cadmium concentration of the electrolyte with a resultant drop in e.m.f. When the concentration of the normal or saturated cell is reached, the e.m.f. should remain constant at 1.01830 volts at 20 deg. cent., but an increase in the temperature coefficient will have been brought about. Some cells drop in e.m.f. more rapidly than 0.003 per cent per annum, and do not come to a constant e.m.f. when the value of the saturated cell is reached; this is due to the systems not having been set up properly. Such cells usually show marked hysteresis effects when subjected to temperature changes, and should be discarded accordingly.

### CARE AND HANDLING OF CELLS

Cells should not be short-circuited as this is likely to upset permanently the original equilibrium of the electrolyte. In a special test three cells short-circuited for ten minutes required seven hours to return to within 0.02 per cent of their original values. (See Fig. 2.) Furthermore, it is best never to draw more than 0.0001 ampere from a cell even if the circuit is closed momentarily only.

Cells should not be exposed to heat even as much as that radiating from an electric light bulb. Such heating, when greater on one side of a cell than on the other, has given rise in unmounted cells to variations of from 0.01 per cent to 0.02 per cent, even though the lamp was rated at only 25 watts and was 15 in. away from one leg of cells. (The exposure was for five minutes only.) Similar effects have been observed in cells mounted in molded cases. Drafts as well as heating due to handling also should be avoided.

Shaking seems to have no effect upon properly made portable cells, provided it is neither too vigorous nor too long. However, after a cell has been shipped, it is better, as a safety measure, to let it stand for two or three days at least before placing reliance upon it.

If an accuracy of at least 0.02 per cent is wished, cells should not be used at temperatures below 15 deg. cent., although even freezing in some cases has seemed to have had no permanently injurious effect. Recovery from cooling, say to about 12 deg. cent., is rapid requiring only an hour or so at the most to restore the proper e.m.f.

This brief discussion may have raised doubts as to the reliability of the cadmium cell as a standard of e.m.f. It is true that the cell is by no means foolproof, but few precision devices are. Ceaseless care must be given to its manufacture, and a thorough knowledge of its chemistry gained in order to insure the maximum of constancy and agreement. Nevertheless, there are few if any other electrical measurements in which so high a precision (0.01 per cent) can be secured with so few precautions as in the determination of e.m.f. by means of a standard cell and some form of potentiometer.

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# Recent Developments in Magnetic Units

**To overcome confusion in the use of electromagnetic units, the International Electrotechnical Commission through its subcommittee on electric and magnetic magnitudes and units has been working for several years toward standardization in definition and nomenclature. In this article, recent actions in that direction are discussed and a brief summary of earlier contingent actions is given.**

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EXAMINATION of the technical literature of the magnetic circuit during the past 30 years shows much ambiguity and misunderstanding among writers in all parts of the world, as to the definition and meaning of the magnitudes of units in general use. In particular, the name "gauss" has been used by some writers for the c.g.s. unit of magnetizing force $H$, by others for the c.g.s. unit of magnetic flux density $B$, and by still others for both $H$ and $B$ indiscriminately. Moreover, the important and much used quantity permeability $\mu$, admittedly defined as the ratio $B/H$, has been regarded by some as having physical dimensions, and by others as having zero dimensions or as being a mere numeric. This confusion

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Prepared especially for ELECTRICAL ENGINEERING and based in part upon the minutes of the London 1931 meeting of the International Electrotechnical Commission held September 18, 1931. *Not published in pamphlet form.*

of definitions apparently has pervaded the literature of all countries. It gives rise to much misunderstanding and perplexity in the study of either basic or applied magnetism. These differences of thought and expression are found in text-books both of physics and of electrical engineering. It is this confusion brought about in electrotechnical literature that is the main source of complaint.

From a practical standpoint, the underlying philosophy of the electromagnetic field is of lesser importance than the arithmetical meaning of the formulas necessarily used in engineering; hence the urgency of international agreement upon the definitions involved, even though it may be admitted that these rest upon mere conventions. This brief and unofficial account of efforts to arrive at such agreement may be of service to readers of electrotechnical journals who may not have been fully informed of what the International Electrotechnical Commission already has been able to accomplish in this direction. It is hoped also that the article may be of value even to those who may read the official minutes, but who are not fully acquainted with the subject's history.

## SUMMARY OF EARLIER ACTIONS IN MAGNETIC UNITOLOGY

At the I.E.C. plenary meeting of 1927, in Bellagio, a proposal was introduced to adopt a unit of magnetic flux $\Phi$ in the practical or volt-ampere-ohm series of units. After discussion, this was referred for consideration and report to a special subcommittee of seven members representing as many different national committees. This subcommittee was unable to reach agreement, but recommended that the questions be studied by all the national committees and be brought up for discussion at the next plenary meeting of the I.E.C., set for 1930 in Scandinavia. (See "Magnetic Circuit Units," A. E. Kennelly, A.I.E.E. TRANS., v. 49, 1930, p. 486-93.)

Accordingly, the subcommittee on magnetic units convened at the 1930 meeting in Scandinavia. Its membership was increased to include twelve countries, and its name was changed to Section B of I.E.C. Advisory Committee No. 1 (nomenclature) on Electric and Magnetic Magnitudes and Units, hereafter referred to as the E.M.M.U. subcommittee.

During June and July 1930 the E.M.M.U. subcommittee held several meetings at Stockholm. Its first action was to agree unanimously on the convention that inasmuch as flux density $B$ and magnetizing force $H$, in free space have different physical dimensions; their ratio $\mu_0$ (space permeability) is a dimensional quantity and not a mere numeric unit. Also it was agreed unanimously that $\mu/\mu_0$, the ratio of the absolute permeability of a magnetic substance to space permeability, should be called its relative permeability and should be taken as a pure numeric. (See "Magnetic Circuit Units Adopted by I.E.C.," A. E. Kennelly, ELECTRICAL ENGINEERING, v. 50, 1931, p. 133.)

After disposing of this permeability question, the E.M.M.U. subcommittee next adopted the names for four c.g.s. magnetic units, either unanimously or by a large majority. These are given in Table I.

**Table I—C. G. S. Magnetic Units Adopted at Oslo in 1930 and Reendorsed at London in 1931**

| Unit | Symbol | Name |
|---|---|---|
| Magnetomotive force | $\mathcal{F}$ | gilbert |
| Magnetizing force | $H$† | oersted |
| Magnetic flux | $\Phi$ | *maxwell |
| Flux density | $B$† | gauss |

*The name "maxwell" had been adopted at Paris in 1900, with the same meaning.

†Script symbols $\mathcal{B}$ and $\mathcal{H}$ sometimes are used, but because of their convenience italic capitals as shown above are recommended.

The name "oersted" had been used in America for the c.g.s. unit of reluctance $\mathcal{R}$ but had not been adopted internationally. It was transferred to the unit of $H$, on the proposal of the Danish committee, partly because Oersted's discovery of 1820 related to $H$ and not to $\mathcal{R}$, and partly to indicate that "gauss" was considered inapplicable to $H$, after having been assigned to $B$ because of their accepted difference of dimensions.

In addition to the foregoing, the E.M.M.U. subcommittee adopted at Stockholm the practical unit of magnetic flux $\Phi$ with the value of $10^8$ maxwells, and with the name *pramaxwell*. It was agreed also to adopt the prefix "pra" as applicable to deriving practical units from corresponding c.g.s. units. Other actions taken concerned reactive power and power factors in a.-c. circuits. These have not been subjected to serious criticism since the Stockholm meeting and already have been adopted, at least to some extent, in various countries. They all are duly set forth in I.E.C. *document R.M.77* (French and English texts).

All of the actions mentioned were reported and unanimously approved at the I.E.C. plenary meeting in Oslo on July 9, 1930.

## EVENTS OCCURRING BETWEEN 1930 AND 1931

Actions taken in 1930 at Oslo regarding magnetic units gave rise to a great deal of discussion in electrotechnical journals throughout the world, and particularly in the pages of the *Revue Générale de l'Electricité*. Criticism centered mainly about two points: That the names of savants should not have been given to units inthe c.g.s. system, but should have been reserved for units in the practical system; and that the name "gauss" should not have been given to the unit of flux density $B$, but to that of magnetizing force $H$, in conformity with established usage in magnetic observatories.

Regarding the first objection, it has been pointed out that although up to and including the year 1893, the date of the Chicago international congress, names of savants were assigned exclusively to practical units, yet owing to the decisions of the Chicago congress that magnetic units should be kept within the c.g.s. system, the names "gauss" and "maxwell" were given purposely at the Paris congress in 1900, to c.g.s. magnetic units. Therefore, the I.E.C. meeting at Oslo merely followed the actions taken at Paris. It has been pointed out also that the earth's magnetic field has been recorded for many years in gauss or gammas of $10^{-5}$ gauss, yet this field always is measured in air, a feebly magnetizable medium; what actually is determined is a terrestrial flux density $B$ in the air. Consequently, although from a practical standpoint the numerical difference between $H$ and $B$ in air may be insignificant, yet no error in principle is created by speaking of the earth's field in gammas referring to $B$.

In view of the differences of opinion elicited by the publication of the decisions reached at Oslo, arrangements were made and announced early in 1931 to all the national committees, for holding a meeting of the E.M.M.U. subcommittee at London in September 1931.

## NEW COMMITTEE ESTABLISHED

In July 1931, the International Union of Pure and Applied Physics met at Brussels and for the first time established an international committee on "Symbols, Units, and Nomenclature" (S.U.N.). This committee elected as its chairman, Sir Richard Glazebrook, and as secretary, Dr. E. Griffiths. Since electrotechnical units fall within the scope of the S.U.N. committee, the members of that committee were invited to attend and participate in the London meeting of the E.M.M.U. subcommittee on September 18, 1931. The chairman and secretary of the S.U.N. committee were able to accept and took part in the meeting, as also the general secretary of the International Physical Union, Prof. H. A. Abraham.

## ACTIONS AT THE LONDON MEETING IN 1931

National committees of ten countries were represented at the opening E.M.M.U. subcommittee meeting in London on September 18, 1931; countries represented were: Denmark, France, Germany, Great Britain, Holland, Italy, Norway, Poland, Sweden, and U.S.A. Proposals considered and actions taken are reviewed briefly in the following paragraphs.

1. A proposal "that the c.g.s. magnetic units and their accepted names as fixed at the Oslo plenary meeting should remain undisturbed." This proposal was voted unanimously, two countries, however, abstaining (Holland and Italy).

2. A proposal relating to a series of practical magnetic units, based upon the volt-second or "pra-" system as adopted at the Stockholm meeting, with the ampere-turn as unit of m.m.f. After a lengthy discussion, during which considerable difference of opinion was revealed, it was unanimously voted to defer action on these practical units until the national committees should have had further opportunity for investigation; however, on the particular question of a practical unit of magnetomotive force $\mathfrak{F}$, and whether a coil of $N$ turns, carrying a steady current of $I$ amperes, should be taken as $\mathfrak{F} = 4\pi NI$ units or merely $\mathfrak{F} = NI$, a vote was called for, on the proposition that it should be the former. Three countries were in favor of the proposal (France, Holland, and Italy) while four voted against it (Germany, Great Britain, Sweden, and U.S.A.); two countries (Norway and Poland) abstained from voting. It is evident that there is much difference of international opinion over this important question.

3. Conventional interpretation of reactive power in unspecified a-c. right-angled power diagrams. The question considered was whether + *j vars* should be taken as signifying inductively reactive power or the reverse when the basis of the diagram is not specified. It was voted unanimously that a convention be adopted, but that decision as to direction be deferred until a new and definite American recommendation should be presented. Some difference of opinion had been raised as to whether the particular direction recommended ($+jP_r$ for inductively reactive power) was the more advantageous choice.

4. Proposed international adoption of the prefixes "ab" and "stat" applied to a practical unit, for the designation of a corresponding unit in the c.g.s. magnetic or in the c.g.s. electrostatic system, respectively. These prefixes have been and are in use to some extent in America, but never have been adopted internationally. For lack of support to the proposal, no action was taken.

At the conclusion of the foregoing considerations it was unanimously voted to ask the central I.E.C. office to invite the cooperation of the International Physical Union to participate in the formation of a joint committee to consider the question of the electrotechnical units under discussion. It was the general hope that there might be close cooperation in the future between the two organizations on all questions in which physics and electrotechnics jointly are involved.

## RESULTS OF THE LONDON MEETING OF 1931

Consequences of the London meeting of the E.M.M.U. subcommittee may be of far-reaching international importance in electrotechnics if they serve, as apparently they should, to terminate the confusion in the use of the c.g.s. magnetic units which has existed in the literature of electromagnetic engineering throughout the world for at least 30 years. The series of names and definitions for these units adopted in 1930 during the plenary meeting at Oslo has been discussed openly in many countries for more than a year, and these were reendorsed without opposition at the London meeting. It is to be hoped therefore that the units as adopted will come into general electrotechnical use.

There remain at least four c.g.s. magnetic units that as yet have received no names (permeance, permeability, reluctance, and reluctivity); but the four units to which definitions and names have been given (see Table I) probably are sufficient for present practical purposes. These are based upon the convention that space permeability is more than a mere number. There remain a certain minority of both physicists and engineers who disagree with that convention; but after so many years of ambiguous reading and writing it would be strange indeed if an immediate unanimity on this difficult question could be obtained in every country. It can only be hoped that a harmonious procedure through international convention will be secured, and this the recent London meeting has endorsed.

From a philosophical point of view, it is curious that the London endorsement of the I.E.C. Oslo action on magnetic units and their underlying convention should have been almost coincident with the London Faraday celebration of 1931. It is admitted generally that Faraday's researches made magnetic flux in space the salient phenomenon in magnetics, whereas the magnetic pole or quantity of magnetism on a polar surface previously had been the dominating concept. It has been suggested that the modern change in underlying convention reflected in the I.E.C. actions may be attributable to the change in views resulting from Faraday's work.

As for the series of practical magnetic units introduced by the adoption at Oslo of the *pramaxwell*, the whole question is to be discussed further by the national committees of the I.E.C. in cooperation, it is to be hoped, with the International Physical Union before proceeding further in that direction. For the present, we may remain well content to work with the c.g.s. system.

# News

## Of Institute and Related Activities

# Summer Convention Offers Attractive Program

FOR THE 48th annual summer convention of the A.I.E.E. to be held at Cleveland, Ohio, June 20–24, 1932, the Cleveland national convention committee has planned a program of entertainment, inspection trips, and recreation, supplementing the excellent technical sessions, all of which should cause this convention to be attractive as a vacation as well as of benefit professionally. Convention headquarters will be at the Hotel Cleveland, located on the Public Square of the city.

### TECHNICAL SESSIONS

Many papers covering a wide variety of interesting subjects in the field of electrical engineering will be presented in nine technical sessions scheduled during the week of the convention. Two of the sessions comprise well arranged symposiums, one on the combined aspects of reliability and economy in the operation of large electric systems; the other on conductor vibration. The former symposium will represent system operating practise in four different localities: Philadelphia, Detroit, Boston, and Chicago. The latter will present valuable data as a result of both laboratory and field investigations.

Besides these symposiums four other sessions, namely, electrical machinery, electrochemistry-electrometallurgy and research, protective devices, and automatic stations, will afford much of unusual interest in the fields of design, theory, research, and operation. The session devoted to communication should have a broad appeal because of the general interest in the subjects to be presented, and in addition, there will be interesting demonstrations. Still another session on selected topics will offer interesting papers, some of the subjects of which have originated in Cleveland and its environs. One of these relates to the method of wiring buildings as an essential to good illumination. Several others pertain to both synchronous motor and induction motor applications and performance.

For the first time in recent years a session will be devoted entirely to education. Even interests outside of the specific confines of the Institute are being attracted to this session which will start with a paper by Dr. W. E. Wickenden, president of Case School of Applied Science. In order to permit all to participate in this session, the three parallel meetings which occur in the morning will not begin until the conclusion of Doctor Wickenden's address.

### ENTERTAINMENT FEATURES

The opening day will stage the beginning of the annual golf tournament at the beautiful Canterbury Club course, and the beginning of the tennis tournament at the University Club courts. Qualifying rounds for the golf tournament must be played Monday. Those not participating in the tournament may play throughout the week at the Canterbury Club, the Mayfield Country Club, and other private courses.

The president's reception followed by dancing will take place Monday evening at the Hotel Cleveland. Tentative plans have been made for a possible boat trip on Tuesday evening.

An innovation this year will be the substitution of social afternoon and evening for men, women, and children, instead of the usual formal banquet. The entertainment is to be staged on the beautiful grounds of Nela Park, with various field events, dinner and dancing included.

Full details of the generous entertainment program and the several novel features planned for the convention will be given in a program folder being prepared by the Cleveland convention committee, and soon to be mailed by that committee.

### LADIES' ENTERTAINMENT

For the ladies a visit to the Art Museum on University Circle, a drive through the residential sections, and an afternoon tea at Shaker Tavern are planned for Monday. Golf, luncheon, and bridge at the Canterbury Club will be available for them on Tuesday, and among the trips arranged for their entertainment on the following days are visits to a model furnished home built in the Builders' Exchange Building, the Terminal Tower, a radio broadcasting studio and a large modern bakery as well as a drive through the beautiful Metropolitan Park system of the West Side.

### INSPECTION TRIPS

Inspection trips for all interested include the entire route of the recent electrification of the Union Terminal, Avon generating station, d-c. and a-c. substations, the new Ohio Bell Telephone building and exchange facilities, strip mills of the Otis Steel Company representing latest developments in electrification of such mills, and a trip to Akron to visit the many interesting places in that city.

In connection with the previously mentioned entertainment at Nela Park, inspection trips will be conducted during the afternoon. On Friday the entire con-

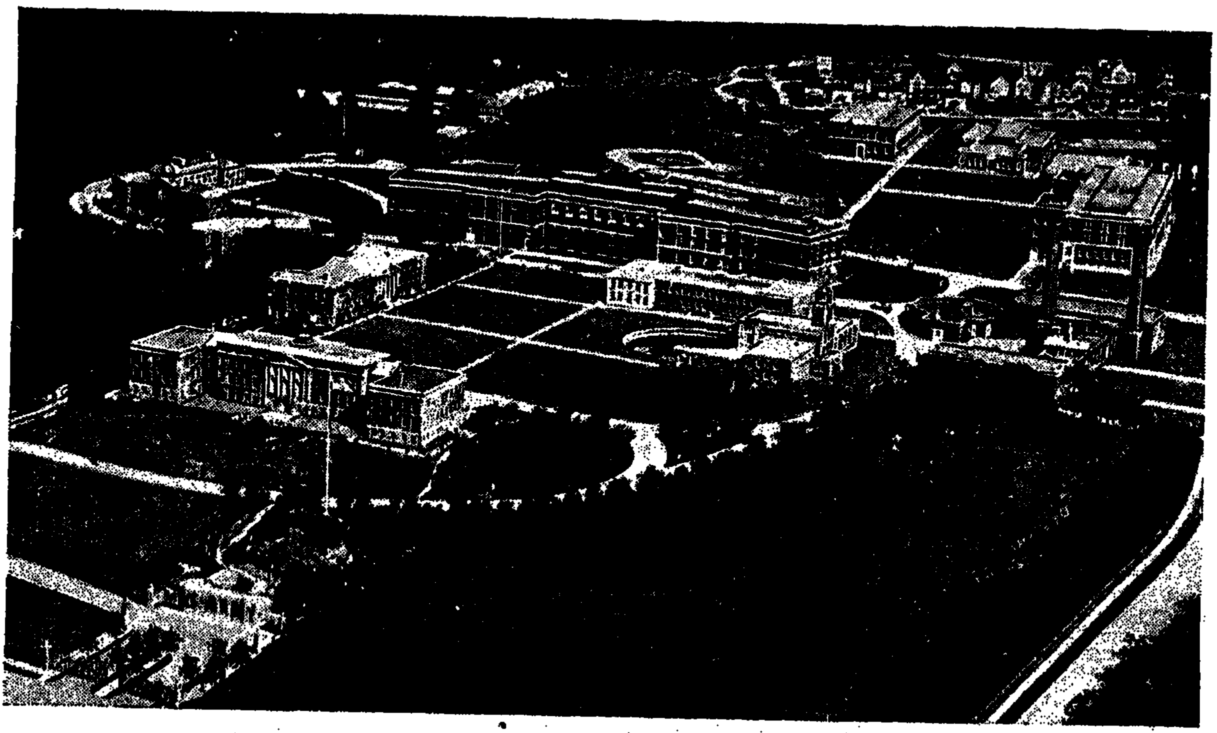
Canterbury Golf Club near Cleveland, Ohio, will be the scene of many hard-fought battles during the rapidly approaching summer convention of the Institute vention will be conducted on a drive through the East Side to observe an abundance of attractive features.

### Registration

There is no registration fee for attendance at the convention. Each member should register in advance by using the post-card to be mailed for that purpose, thus assisting the necessary advance preparation. Registration for the various sports also should be made on the card.

In connection with the entertainment features of the convention there will be a charge of $5 per person, payable upon registration. This fee covers all features except greens fees, and includes the special feature on Thursday which will replace the usual formal banquet.

All hotels noted in the accompanying table are within a five-minute walk of convention headquarters. Reservations for hotel accommodations should be made by writing directly to the hotel preferred.



**Nela Park, in Cleveland, where a novel entertainment feature will be staged this year during the afternoon and evening of Thursday, June 23**

Reduced railroad rates on the certificate plan will be available for those attending the meeting, and summer tourist fares at a lower rate will be in effect from certain western states.

## Program

All technical sessions and the opening of the convention will be held at the Hotel Cleveland. All events are scheduled in *Eastern Standard Time.* Abstracts of papers to be presented at the sessions are scheduled for publication in the June 1932, issue of Electrical Engineering.

| Hotel | Rooms | Single | Double |
|---|---|---|---|
| Cleveland (headquarters) | 1,000 | $3.00–$ 8.00 | $4.50–$10.00 |
| Hollenden | 1,050 | 3.00– 5.00 | 5.00– 9.00 |
| Statler | 1,300 | 3.50– 10.00 | 5.50– 10.00 |
| Winton | 525 | 2.50– 4.00 | 4.00– 5.50 |
| Allerton | 550 | 1.50– 3.00 | 2.50– 4.00 |
| Auditorium | 300 | 2.00– 3.00 | 3.50– 5.00 |
| Olmstead | 300 | 2.00– 3.00 | 4.00– 6.00 |

Hotel rates are for rooms with bath, European plan. Reservations for accommodations should be made by writing directly to the hotel preferred.

### Monday, June 20

**9:00 a.m.—Registration**

**10:00 a.m.—Opening Session**

Annual business meeting of the Institute

Annual report of the board of directors (in abstract)

Report of tellers' committee on election of officers; introduction of and response from president-elect.

Presentation of prizes for papers

Lamme Medal presentation

President's address, by C. E. Skinner

**2:00 p.m.—Conference of Officers, Delegates, and Members**

Inspection trips

**Evening—President's Reception**

### Tuesday, June 21

**9:30 a.m.—Special Session**

*Address on Education—W. E. Wickenden, president, Case School of Applied Science.

**10:15 a.m.—(A) Education**

*The Engineering Subjects, Electrical and Cognate in the Four-Year College Program of Electrical Engineering, A. H. Lovell, University of Michigan

Educational Aspects of Engineering and Management, R. E. Doherty, Yale University

†*Adult Technical Education in Metropolitan Areas, O. W. Eshbach, American Telephone & Telegraph Co.

**10:15 a.m.—(B) Symposium on Combined Aspects of Reliability and Economy in the Operation of Large Electric Systems**

Philadelphia Electric Company's System, J. W. Anderson and Herbert Astrada, Philadelphia Electric Co.

The Detroit Edison Company's System, A. P. Fugill, Detroit Edison Co.

The Edison Electric Illuminating Company of Boston's System, R. E. Dillon, The Edison Electric Illuminating Company of Boston

Chicago District, L. L. Perry and F. V. Smith, Sargent and Lundy, Inc.

**10:15 a.m.—(C) Electrochemistry—Electrometallurgy and Research**

*Electrical Equipment for Precipitation Service, H. Speight, Westinghouse Electric & Mfg. Co.

*Oxide Coatings on Aluminum, J. D. Edwards, Martin Tosterud and H. K. Work, Aluminum Company of America

*Calculation of Inductance and Current Distribution in Low Voltage Connections to Electric Furnaces, C. C. Levy, Westinghouse Electric & Mfg. Co.

*New Applications of Non-linear Circuits to Relay and Control Problems, C. G. Suits, General Electric Co.

**2:00 p.m.—Conference of Officers, Delegates, and Members (cont'd)**

Inspection Trips

### Wednesday, June 22

**9:30 a.m.—(D) Electrical Machinery**

The Coordination of Transformer Insulation With Line Insulation, V. M. Montsinger, General Electric Co., and W. M. Dann, Westinghouse Electric & Mfg. Co.

*Coordination of Distribution Transformers, E. D. Treanor and W. H. Cooney, General Electric Co.

*Load Ratio Control Circuits, L. F. Blume, General Electric Co.

Influence of Brush Contact Drop on Commutation, L. R. Ludwig and R. M. Baker, Westinghouse Electric & Mfg. Co.

*Single-Phase Short-Circuit Torques of Synchronous Machines, C. A. Nickle and M. L. Henderson, General Electric Co., and C. A. Pierce, Worcester Polytechnic Institute

†Transient Analysis of A-C. Machinery II, Extension to Salient-Pole Machines, Yu H. Ku, University of Chekiang

**9:30 a.m.—(E) Communication**

*Wire Communication Aids to Air Transportation, H. H. Nance, American Telephone & Telegraph Co.

*Characteristics of Electromagnetic Radiation From Aircraft in Flight, J. C. Coe and T. C. Rives, Signal Corps, War Department

*Vertical Sound Records, H. A. Frederick and H. C. Harrison, Bell Telephone Laboratories, Inc.

**2:00 p.m.—Trip to Akron**

## Notice of Annual Meeting

The annual meeting of the American Institute of Electrical Engineers will be held in the Hotel Cleveland, Cleveland, Ohio, at 10 a.m. on Monday, June 20, 1932. This will constitute one session of the annual summer convention, which is to be held this year in Cleveland, June 20–24.

At this meeting the annual report of the board of directors and the report of the committee of tellers concerning the ballots cast for the recent election of officers will be presented.

Such other business, if any, as properly may come before an annual business meeting may be considered.

(Signed) H. H. Henline
*Assistant National Secretary*

**Thursday, June 23**

**9:30 a.m.—(F) Selected Subjects and Technical Committee Reports**

*Adequate Wiring of Buildings, An Essential for Good Illumination, G. H. Stickney and Walter Sturrock, General Electric Co.

*Induction Motor Versatility—The Nature of Its Applications, E. W. Henderson, The Reliance Electric and Engineering Co.

Dynamic Braking of Synchronous Machines, E. E. Kilbourne and I. A. Terry, General Electric Co.

**9:30 a.m.—(G) Protective Devices**

Application of High Speed Relays, G. W. Gerell, Union Electric Light and Power Co.

A High Speed Reactance Relay, A. R. van C. Warrington, General Electric Co.

†Relay Operation From Bushing Potential Devices, P. O. Langguth and V. B. Jones, Westinghouse Electric & Mfg. Co.

†Operation of Relays From Carrier-Current Coupling Capacitors and Capacitance Transformer Bushings, J. E. Clem and R. M. Cordray, General Electric Co.

The Boric Acid Fuse, A. P. Strom and H. L. Rawlins, Westinghouse Electric & Mfg. Co.

**Afternoon and Evening—Entertainment at Nela Park**

**Friday, June 24**

**9:30 a.m.—(H) Automatic Stations**

*Torque Balance Telemetering, A. J. Johnston, General Electric Co.

*Developments in Two-Wire Supervisory Systems, J. H. Oliver, General Electric Co.

*Operating Experience With Supervisory Control on the Reading-Philadelphia Suburban Electrification, J. E. Pastoret, Reading Co.

*The Application and Performance of Automatic Equipment at Stations and Substations on The American Gas and Electric Company's System, Philip Sporn, Basil Lanphier and H. E. Turner, American Gas and Electric Co.

**9:30 a.m.—(I) Symposium on Conductor Vibration**

Stress-Strain Studies of Transmission Line Conductors, G. W. Stickley, Aluminum Research Laboratories

Vibration and Fatigue in Electrical Conductors, A. E. Davison, J. A. Inglis, and V. M. Martinoff, Hydro-Electric Power Commission of Ontario

*Vibration of Overhead Transmission Lines, R. A. Monroe and R. L. Templin, Aluminum Company of America

*Transmission Line Vibration Due to Sleet, J. P. Den Hartog, Westinghouse Electric & Mfg. Co.

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* These papers are under consideration for presentation at the summer convention, but up to date of going to press have not been officially placed upon the program.

† These papers will not be published in the Transactions or in advance form by the Institute but copies may be made available by the respective authors.

### Rules on Presenting and Discussing Papers

At the technical sessions papers will be presented in abstract, ten minutes being allowed for each paper unless otherwise arranged, or the presiding officer meets with the authors preceding the session to arrange the order of presentation and allotment of time for papers and discussion.

Any member is free to discuss any paper when the meeting is thrown open for general discussion. Usually five minutes are allowed each discussor. When a member signifies a desire to discuss papers on other subjects or groups, he shall be permitted a five-minute period for each subject or group.

It is preferable that a member who wishes to discuss a paper give his name beforehand to the presiding officer of the session at which the paper is to be presented. Copies of discussion prepared in advance should be left with the presiding officer. Each discussor is to step to the front of the room and announce, so that all may hear, his name and professional affiliations. Discussions at the technical sessions are not reported. To be considered for publication, discussions should be written and mailed to the A.I.E.E., Editorial Department, 33 West 39th Street, New York, N. Y., on or before July 8, 1932.

# Summarized Review of Some Milwaukee Meeting Discussions

PRINCIPAL discussions of Milwaukee District meeting papers are summarized herewith. The papers to which these discussions refer were abstracted in Electrical Engineering for March 1932, p. 188–92. Additional articles based upon these papers are being presented in subsequent issues.

Only discussion submitted in writing in accordance with governing A.I.E.E. rules is summarized. Complete discussion together with all approved papers will be published in the Transactions.

### Toll Switching Plan for Wisconsin

In connection with this subject E. W. Neubauer (Chicago, Ill.) discussed several features in effect under the toll switching plan in Illinois. He explained that one of the important results of the application of the toll switching plan is the improved toll service to small communities located somewhat away from the larger cities.

Glen Ireland (New York, N. Y.) discussed the general toll switching plan as a whole which covers the entire United States and eastern Canada. Only a few per cent of the circuit groups required to complete the routing arrangements of the general toll switching plan within the Bell System remain to be placed, and these represent less than 1 per cent of the circuit miles now in service. He referred also to the excellent progress that has been made in providing terminal repeater-switching pad arrangements at the more important switching centers throughout the country.

R. C. Siegel (Milwaukee, Wis.) also discussed this subject and cited advantages of the toll switching plan. He explained that limiting switching to fewer toll centers results in the concentration of larger numbers of toll circuits on a smaller number of main routes and the concentration of equipment in fewer central offices. Plans in Wisconsin within the next few years and ultimate planning also were discussed briefly.

### Police Teletypewriter Communication

E. W. Neubauer (Chicago, Ill.) discussed this subject and referred to the various types of systems in use. The particular telegraph line system used for each link depends largely upon the length of the circuit and the type of telephone wires in use between the terminals. Maintenance methods for these police systems were explained and the importance of continuity of service at all times emphasized.

J. O. Carr (Park Ridge, Ill.) cited the many advantages from the use of this system by comparison with the older method of broadcasting and rebroadcasting telephone messages which permitted human error to enter into the problem and required a longer period of time on the receiving end of the system.

### Weather Resistant Insulation for Line Wires

C. D. Brown (Milwaukee, Wis.) stated that his experience with the use of tree wire indicated that its outer covering had in many cases the same deficiencies with respect to impregnating compound as was brought out in the paper regarding weatherproof insulation. He inquired if investigation had been made of the properties of the weather resistant covering for tree wire, and if so, what were the results?

James H. Foote (Jackson, Mich.) also discussed this subject and it is his belief that seven years' life of weatherproofing on overhead wire would seem to be abnormally short. He cited a case where triple braid weatherproof had been in service eighteen years without showing any appreciable amount of raggedness or deterioration easily visible from the ground.

### Waukegan Station

A. H. Lovell (Ann Arbor, Mich.) believed that to one not familiar with Chicago and its western surroundings, the choice of only 25,000-kw. units in 1923 and 65,000-kw. units in 1930 was puzzling. The authors were asked to discuss this reference to the size of the load in Chicago at those times.

W. S. Monroe (Chicago, Ill.) brought out that the history of this power station represented in a large measure the development of the power station industry in the Chicago district so far as steam pressure and steam temperature are concerned and the change of boiler furnaces from chain grate stoker to pulverized coal. He also explained that the last three units installed, numbers 3, 4, and 5, were each the largest single shaft units available at the time they were ordered.

### 115,000-Kw. Turbo-Alternator

S. H. Mortensen (West Allis, Wis.) discussed several of the design features of this generator which brought about a reduction of vibrations, stray fields, heating, etc. The advantages of substituting non-magnetic for magnetic coil supporting rings on the leakage fields and stray losses of a 2,500-kva., 3,600-r.p.m. generator were shown with curves.

One of the many points of interest discussed by C. J. Fechheimer (Milwaukee, Wis.) was the possible influence of the foundation of this generator, on its critical speed. He believes that in all probability the running speed is above the first critical speed and that it is important to remember that the influence of the foundation might lower the critical speed, and then there would be danger of encountering a higher critical speed near the running speed.

Philip Sporn (New York, N. Y.) inquired whether the use of hydrogen was given consideration in connection with the design. He believes that in addition to the improved performance of an 18-kv. winding possibly hydrogen would have raised the efficiency to a figure as high as 99 per cent and increased the rating by well over 1,000 kw. which would have justified considerable extra expenditure.

### Mercury Rectifiers for A-C. Railways

In connection with the use of rectifiers instead of commutators L. R. Ludwig (East Pittsburgh, Pa.) considers the rectifier as a unidirectional switch whereas the commutator and brush he pointed out would pass current in either direction. Also the rectifier for practical reasons must have a comparatively small number of anodes or segments, whereas the commutator usually has many. Therefore, the utilization of the windings on the motor it is believed would not be nearly so good as if a commutator were used.

R. E. Hellmund (East Pittsburgh, Pa.) discussed the scheme proposed in this paper and pointed out that while considerable progress has been made in the development of rectifiers and similar electronic devices, however, perhaps even greater advances have been made in the design of single-phase motors. It is believed that their relative position today is about the same as in the early days and that present rectifier arrangements cannot compete economically with single phase commutator motors.

E. F. W. Alexanderson (Schenectady, N. Y.) is of the opinion that this development will lead to a practical solution because progress of the vacuum tube technique is rapidly leading to new and superior forms which in their turn make possible improved methods of correlating the power system, the vacuum tube, and the motor.

R. G. McCurdy (New York, N. Y.) discussed the probable inductive effects that would result from the use of the controlled grid mercury arc rectifier which may be expected to complicate the problems of coordination between single-phase a-c. railways and telephone circuits.

H. M. Trueblood (New York, N. Y.) in connection with this subject analyzed several factors and general observations based upon a comparison of the use of single-phase 25-cycle and 60-cycle energy upon the contact wire of an electrified railway using the running rails for return.

### Mercury Rectifiers Versus Rotary Converters

D. C. West (East Pittsburgh, Pa.) emphasized the statements in the paper regarding the importance of service reliability. He also pointed out that within the past few years, the results of many years of development effort have brought the rectifier substation to the point where its existence is thoroughly justified throughout the field of d-c. railway power supply.

W. E. Gutzwiller (Milwaukee, Wis.) presented data which showed that the operating costs and service failures of the rectifiers mentioned in this paper were rather high in comparison with similar, but more modern, stations.

### A 60-Cycle Transmission System

C. L. Fortescue (East Pittsburgh, Pa.) discussed the protective features of the line of the Milwaukee Electric Railway and Light Company described in the paper. He believes the spacing and height of the ground wires above the line wires should produce good shielding effect. Also as a large part of the line follows the railroad right-of-way, good grounding should be obtained and with the liberal tower clearances, a good record against lightning should be obtained with this line.

### Insulator Sparkover

C. L. Fortescue (East Pittsburgh, Pa.) also discussed this subject and is of the belief that these papers cover research producing data which has been greatly needed by the industry; namely, the effect of humidity upon the 60-cycle flashover of different types of insulating structures.

In regard to this subject, A. O. Austin (Barberton, Ohio) pointed out that where humidity is high it is very important in making the tests that insulators be at room temperature, as otherwise large discrepancies may arise.

Philip Sporn (New York, N. Y.) referred to previous discrepancies in 60-cycle flashover of insulators as given by different manufacturers. Subsequent work of the lightning and insulator subcommittee showed that this was due largely to the different humidity conditions under which tests were made. Mr. Sporn believes that this paper definitely confirms the point and shows how consistently the results appear when plotted against relative humidity.

### A Limiting Gap for Station Apparatus

C. L. Fortescue (East Pittsburgh, Pa.) complimented the author on the good work which he had done, especially in pointing out the necessity of coordinating insulation for positive as well as negative surges.

W. L. Lloyd, Jr. (Pittsfield, Mass.) does not agree with conclusions 1 and 3 giving the requirements which an ideal gap should have and its use in the station; he believes also that a great many tests would be necessary before one could be certain that conclusion 2 was justified. It was felt that the value of the paper might possibly have been enhanced if the measured test points of the curves had been given.

J. T. Lusignan (Mansfield, Ohio) analyzed the two principles involved in connection with the control type of limiting gap which provides for a wide variation of electrostatic field in order to secure practically any sparkover characteristic desired. Reference was made to several simple gap arrangements to illustrate the effect of uniformity of voltage gradient across the gap upon time lag of the gap; also to illustrate the effect of an unsymmetrical electrostatic field upon the polarity at which a gap will have a lower breakdown voltage.

J. J. Torok (East Pittsburgh, Pa.) emphasized the importance of the following points in the paper: first, the differences between the positive and negative flashover characteristics of various gaps and their importance in coordination; second, the relations of flashover between waves of various durations and the volt-time curve obtained by a flat-topped wave.

J. F. H. Douglas (Milwaukee, Wis.) discussed this paper and he believes that the different behavior of points and spherical electrodes with positive and negative electrification were clearly shown to be in accord with the electrostatic field theory, and were verified amply by experimental tests. He thought that future work might well be directed toward some of the details which are not yet fully explained.

### Diameter and Spacing of Insulators

C. L. Fortescue (East Pittsburgh, Pa.) in his discussion of this subject emphasized that there was nothing untried in the type of insulators proposed. He explained that insulators of this diameter and larger have been in use on the Pacific Coast, giving good service; and they are just as sturdy as the standard 10-in. suspension insulator.

N. B. Obbard (of the American Bridge Company) discussed this subject in its relation to tower design. He believes this paper is one of the first in which the economic relation of the insulator string to the cost of the tower has been taken into consideration, and that both insulators and tower design should be considered at the same time and not as separate problems.

Another discussion of this subject by A. O. Austin (Barberton, Ohio) also pointed out that with the more efficient insulator it is possible to reduce the clearances and the height of tower, so that the probable number of hits to the line will be less. Also with less clearance the line reactance is reduced and capacitance is increased, so that more power may be transmitted and the stability bettered.

In connection with the part of this paper which deals with the question of diameter and spacing, Philip Sporn (New York, N. Y.) believes that the value of this information would have been greatly enhanced had the tests been confined to practical designs and to spacings and diameters within the commercial range.

W. L. Lloyd, Jr. (Pittsfield, Mass.) discussed the wave shapes used for the tests in this paper. With regard to the wave shape shown in Fig. 1-B, he believes that sparkover of a test piece would take place at or near the crest of such a wave or not at all; consequently, high sparkover values and impulse ratios are obtained. The laboratory wave shown in Fig. 2, he believes, should give values lower than those measured in the field.

FLASHOVER VALUES OF INSULATORS

A. O. Austin (Barberton, Ohio) in discussing the subject of normal frequency flashover values of insulators as affected by humidity and size, explained that there are so many factors involved which affect the flashover of an insulator that general laws cannot be established which apply to all types of insulators. The correction for humidity therefore must be determined largely by test on the particular insulator or one approximating its general characteristics.

Philip Sporn (New York, N. Y.) believes that this paper checks closely with the information furnished by Mr. Lloyd's paper. He believes that plotting data on the behavior of insulators under different humidity conditions against abscissas of vapor pressure is certainly the most scientific manner of presenting the data.

Another discussion of this subject by J. C. Rah (Chicago, Ill.) brought out that the results obtained on insulators from experiences of many observers indicated that air spaces are responsible for reduced flashover rather than wet surfaces, and therefore the wet flashovers are entirely a function of design.

# Summarized Review of Some Winter Convention Discussions—Continued

PRINCIPAL discussions of the majority of winter convention papers were summarized in ELECTRICAL ENGINEERING for April 1932, p. 272–9. The remainder is presented herewith. The papers to which these discussions refer were abstracted in ELECTRICAL ENGINEERING for January 1932, p. 39–49 and February 1932, p. 130–2, excepting only the papers given more complete treatment in these same issues; additional articles based upon these papers are being presented in subsequent issues.

Only discussion submitted in writing in accordance with governing A.I.E.E. rules is summarized. Complete discussion together with all approved papers will be published in the TRANSACTIONS.

## Electrical Machinery

PARALLELED ROTOR AND STATOR

In connection with this subject H. B. Hall (New Haven, Conn.) pointed out that the same performance as the authors obtain may be secured from a normally connected induction motor by running it on $\sqrt{2}$ times normal voltage. This, he explained, could be done to any induction motor even if its rotor and stator were wound for different voltages or if it had a squirrel cage rotor.

R. E. Hellmund (East Pittsburgh, Pa.) considered the probability of this special arrangement being used for general purpose work which he believes does not seem likely because usually the same results can be obtained with the ordinary induction motor. Nevertheless he thinks it might be useful in special cases, as, for instance, where speed-torque characteristics as shown in Fig. 12-C of the paper are desirable; therefore the publication of the results obtained should be considered a welcome
on to the art.

ortescue (East Pittsburgh, Pa.)
sed this subject and analyzed
y the method of symmetrical
It was shown that the output
e copper loss was increased
41.4 per cent. To offset this the inductance was doubled but the rotor iron loss and the stator iron loss would have approximately the same magnitude, so that the iron loss for the same applied voltage would be approximately double that in the regular induction motor.

DAMPER WINDINGS FOR MOTORS

M. R. Lory (East Pittsburgh, Pa.) said that the problem of the designer was to meet the torque requirements of the load and still keep the current drawn from the line to a minimum. He believes the paper gave a comprehensive summary of the various means by which the designer can accomplish this result. As a matter of interest in connection with two double-deck arrangements in the paper the discusser explained that he had calculated these two examples with two bars in parallel but in separate slots, making the permeance of the slot above each the same as the permeance which it has in the arrangement given in Fig. 7 of the paper. The values of the constants for the two bars were given.

Another discussion of this subject by R. E. Hellmund (East Pittsburgh, Pa.) answered the question as to why the various exciter and phase-advancer schemes for induction motors have not been commercially exploited in this country. He expressed belief that this paper is further evidence of the excellent progress which continuously has been made by American designers of synchronous motors in the development of motors suitable for the many commercial applications.

POWER TRANSFORMER DESIGN

R. E. Hellmund (East Pittsburgh, Pa.) in his discussion of this subject drew comparisons between the methods of surge testing now arrived at in this country, and those which were in effect with most manufacturing concerns in Europe during the summer of 1925. The practise now arrived at in this country is, as a result of the more deliberate method of developing it, in marked contrast to the European methods, and in regard to transformers, it is much more rigorous.

F. W. Peek (Pittsfield, Mass.) in his discussion of this subject attributed the paper by Palueff and Hagenguth as one of a pioneer series which has placed the subject of transients in transformer windings upon a scientific and engineering basis. In the light of new knowledge resulting from this series of papers the discusser again recommended that the committee on electrical machinery set up methods, waves, etc., for making a lightning test on transformers if such a test should seem desirable.

Another discussion by C. L. Fortescue (East Pittsburgh, Pa.) reviewed the historical background leading up to the present development of surge-proof insulation and winding in transformers. The other phase of Mr. Fortescue's interesting discussion predicted in the light of present knowledge the magnitude of the surges to which a transformer might be exposed in certain situations. His remarks were confined to transformers designed for 110-kv. operation, and the analysis considered only direct strokes on both wood pole and steel tower line construction. The latter was classified into three conditions, namely, unprotected lines, imperfectly protected lines and well protected lines.

F. W. Gay (Newark, N. J.) discussed this subject and proposed to provide a transformer with a resistance path in parallel with a winding to be protected, and electrostatically couple the resistance path with the winding and with the transformer terminals, so that relatively very great currents will pass to charge the winding for high frequency surges but relatively insignificant current will pass through the resistance at normal frequency. A surge winding of relatively few turns with the high frequency winding coupled to the transformer terminals by condensers also could be wound in juxtaposition with the many-turn low-frequency high-voltage winding. Thus an advantageous shunt path of very low surge impedance would be provided through the condenser and high-frequency few-turn surge winding.

A. B. Hendricks, Jr. (Pittsfield, Mass.) did not believe that some of the fundamental improvements claimed in the surge-proof construction were new. He submitted drawing of several test transformers, one of which he designed, built and put in service in 1906 to exemplify the fundamental principles involved. He described the winding which was of the concentric form with circular coils with insulation varied more or less in proportion with the voltages. By the use of interleaved cylinders, flanged rings and formed insulating casing, it presented an absolute barrier between the high voltage winding, low voltage winding, and core.

## Electrochemistry and Electrometallurgy

LOSSES IN ELECTROLYTIC CONDENSERS

J. Slepian (East Pittsburgh, Pa.) discussed this paper and he told of work which he carried on about twelve years ago in connection with the high power factor usually obtained. He found that the addition of a fractional per cent by weight of a soluble fluoride had an extremely beneficial effect upon the power factor and reduced the losses so that cells were made with power factors under 2 per cent. However, these cells with superposed d-c. excitation would not stay efficient and in the course of a year the power factor would become 5 or 6 per cent, and it would continue to rise slowly for years afterward. Investigation showed that there was a change in electrolyte which was assumed to have been the formation of colloidal aluminum hydroxide and the inquiry was made as to why such a substance should effect the losses in the cell.

H. H. Race (Schenectady, N. Y.) also discussed this paper with reference to an explanation of the power-factor frequency characteristics of electrolytic capacitors. He believes that if the coefficients of capacitance and resistance in Fig. 25 of the paper could be assumed to be independent of frequency then the complicated combination of series and parallel arrangements of resistance and capacitance could be reduced to an equivalent circuit. On the other hand he does not believe that the coefficients in Fig. 26, which may be only a special case of a more general form, could be assumed to be independent of frequency since the ionic concentration at a given point in the oxide film would change with time.

### ELECTRICAL PRECIPITATION

J. J. Torok (East Pittsburgh, Pa.) discussed this subject and believes that the authors presented very effectively the results of their experiments. He reviewed a treatise on this subject by Ladenburg which attacked the problem from a different point of view than that taken by the authors of this paper. From this analysis it was found that in precipitators the larger particles would be removed first and as time progressed the smaller particles also would be taken out.

Another discussion by J. C. Hale (Bound Brook, N. J.) took exception to a number of conclusions reached in the paper as well as some of the authors' equations. One of the points questioned by the discusser concerned the mathematical analysis leading to eq. 15 in the paper which shows that identical efficiencies will obtain whether precipitator units be connected in series or in parallel or in series parallel with respect to gas flow, provided the gas is properly divided in the case of unsymmetrical arrangements. For example, in a problem requiring a very low friction loss, eq. 15 points to the use of a large number of units in parallel. The discusser explained that it could be shown mathematically that the combined efficiency of parallel units decreases rapidly as the gas distribution becomes unequal. Equal distribution of gas through too many parallel units was believed to be most difficult and the selection of a proper number of units to be parallel was therefore not a matter of efficiency calculated on the basis of any formula, but a matter of experience with regard to distribution. The discusser felt that in justice to the scientists and engineers, who have devoted much work to the art that the part of the authors' conclusion which referred to work done heretofore should be sincerely questioned.

## Transportation

### THREE-POWER LOCOMOTIVES

W. S. H. Hamilton (New York, N. Y.) discussed the requirements and performance of these locomotives used by the New York Central around New York City. He explained that the size of the internal power plant (300 engine hp.) was based on requirements in the 60th Street yard where there was heavy switching and float work.

With regard to the ability of the internal power plant to meet emergency conditions it was explained that these locomotives successfully handled 2,000-ton trains in regular road service over a distance of 8 miles for a period of 11 months. It was pointed out that for the year 1931 the whole fleet of 36 locomotives was in service with crews on 61 per cent of the time and were available for service 85.5 per cent of the time. This performance with new locomotives and new crews was considered very creditable.

Another discussion of this paper by D. P. Orcutt (New York, N. Y.) considered the expected battery life on the three-power locomotive as compared with the straight storage battery locomotive for switching service. Data on the operation of the first three-power locomotive on the New York Central showed that in switching service about 85 per cent of the energy used by the traction motors flowed directly from the generator to the motors and 15 per cent from battery to the motors. This permits the use of a much smaller battery with a three-power unit, thus greatly reducing battery maintenance cost from that with a straight battery locomotive in switching service.

F. H. Craton (Erie, Pa.) discussed this subject and briefly described requirements in connection with the New York Central's west side improvement which were largely responsible for the development of the three-power locomotive. In comparing the three-power locomotive to the two-power design it was brought out that the engine-generator-battery type was best fitted for operation in service where peak demands are high and the load factor low. The three-power type also possesses the additional advantage of being able to operate on battery power into buildings or restricted areas.

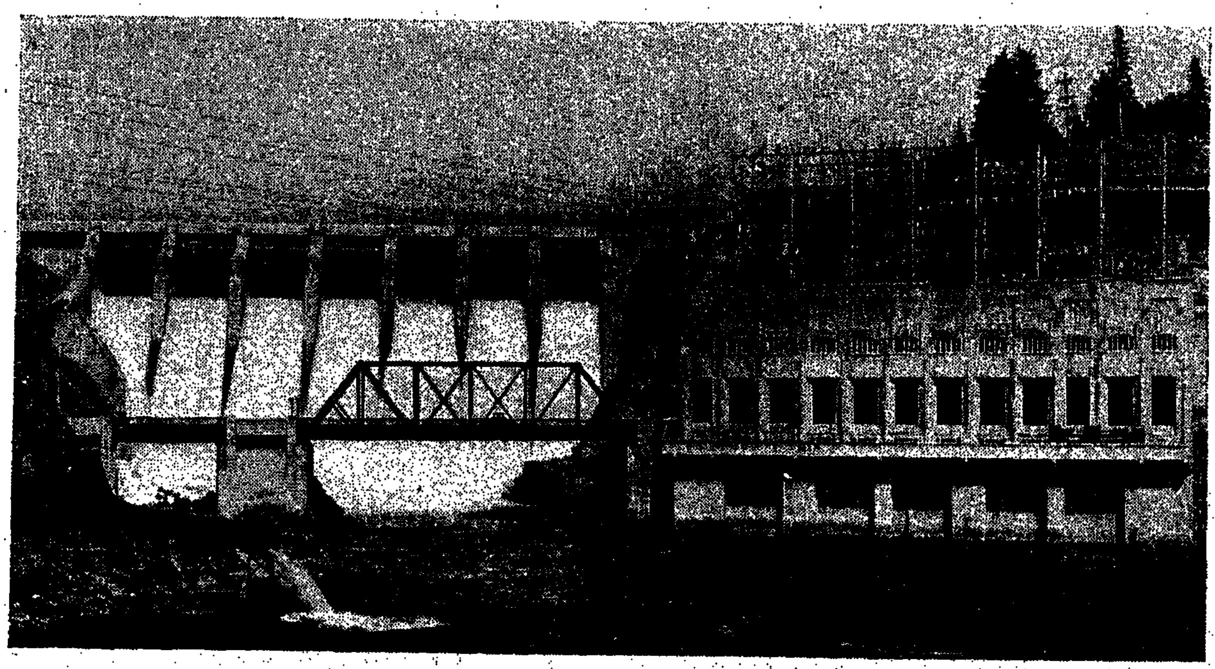
F. H. Brehob (Erie, Pa.) also discussed the subject and described a number of the difficult problems in mechanical design that had to be solved to meet the severe service requirements. The locomotive as developed represents the heaviest four-axle swivel truck locomotive in service today and it utilizes the heaviest axle loading using single-geared axle-hung motors. The weight in working order was limited to 257,000 lb. by utilizing material to best advantage.

Herman Lemp (New York, N. Y.) also discussed the paper and considered the advantages of another engine equipment of 300 hp. to take the place of the battery. He explained that this would not cost or weigh more than the battery which was good only for four years, while the engine equipment if properly maintained would be available at least for ten years.

### TEMPERATURE RISE OF RAILWAY MOTORS

John Basta (East Pittsburgh, Pa.) discussed this subject and explained that the actual heat runs used for verifying the calculated curves, however, did not give more than two, and in some cases even only one point. It was suggested that the author undertake another series of tests in which complete curves would be obtained. Instead of measuring the resistances of armature windings, as was done in the tests

## On Program for the Pacific Coast Convention



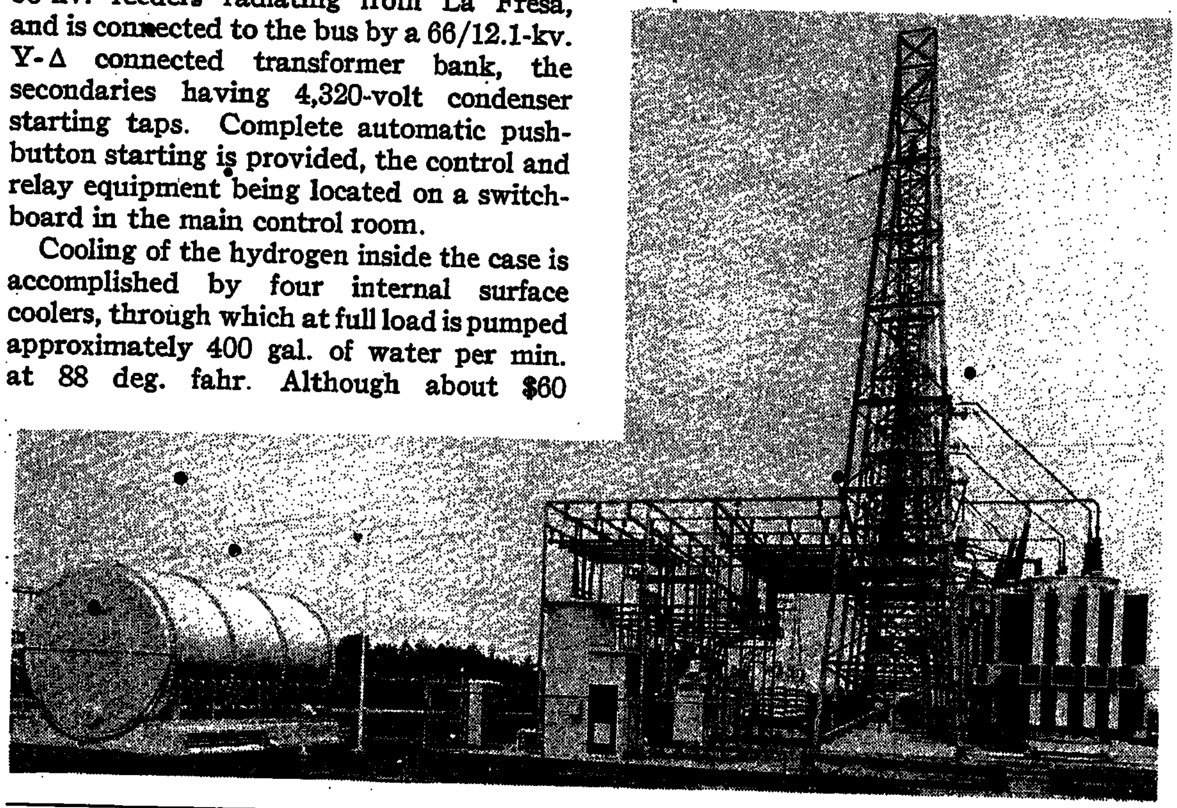
THE RUSKIN hydroelectric plant of the British Columbia Electric Railway Company may be visited by those attending the A.I.E.E. Pacific Coast convention which is planned to be held Aug. 30–Sept. 2, 1932, at Vancouver, B. C. One 47,000-hp. unit is now installed in the Ruskin plant, the ultimate capacity of which will be 188,000 hp. in four units.

# 50,000-Kva. Hydrogen-Cooled Condenser at La Fresa

Reduction of noise, reduced operating temperatures, decreased windage losses, increased efficiency, saving in installation cost, and elimination of the requirement for special fire-fighting equipment are among the benefits secured with this outdoor hydrogen-cooled synchronous condenser. Located at the La Fresa substation of the Southern California Edison Company, Ltd., this condenser is rated 50,000 kva., and is the largest hydrogen-cooled unit ever constructed. It is used for voltage regulation and power factor correction of the 66-kv. feeders radiating from La Fresa, and is connected to the bus by a 66/12.1-kv. $Y$-$\Delta$ connected transformer bank, the secondaries having 4,320-volt condenser starting taps. Complete automatic push-button starting is provided, the control and relay equipment being located on a switchboard in the main control room.

Cooling of the hydrogen inside the case is accomplished by four internal surface coolers, through which at full load is pumped approximately 400 gal. of water per min. at 88 deg. fahr. Although about $60 worth of hydrogen is needed to fill the machine, the cost of make-up hydrogen has averaged less than 10 cents per day during the first 4 months of operation.

The condenser and starting and running circuit breakers were manufactured by the General Electric Company, and the transformers by the Westinghouse Electric and Manufacturing Company. Four 1,250,000-cir. mil. 16-kv. Kerite insulated cables in parallel are used for each of the three main condenser leads.



presented, it was suggested that temperature detectors be placed into the winding which would be connected through slip-rings to meters, so that the distribution of temperatures along the winding could be ascertained at the same time.

C. J. Fechheimer (East Pittsburgh, Pa.) discussed several of the author's assumptions made in the paper. It was believed essential to make assumptions such as the author had done although these might not be the ones to adopt for some other class of apparatus. It was explained that the author's results were all based upon the average copper temperature as measured by resistance. For machines having long cores, the copper at the middle is usually at considerably higher temperature than the average, and consequently assumption *B* in the paper would introduce too large an error.

### Sectionalizing of Rectifier

A. W. Hull (Schenectady, N. Y.) discussed the part of the paper which related to the fundamental limitation of rectifiers, namely, the prophecy that "the major disadvantages which go with size appear to be fundamental and permanent. Larger units will always be less efficient and probably less reliable." He explained why theory and present experience did not seem to him to justify this conclusion. He believed that if large rectifiers were at present less efficient than small ones, it was a mere chance which was due to the relative state of development, and not a fundamental limitation of large rectifiers.

R. E. Hellmund (East Pittsburgh, Pa.) discussed the reliability and availability of the sectionalized designs versus large units. He cited as an analogy, discussion which took place in the early days of a-c. main-line electrification regarding the relative merits of locomotives having one or two large motors and those having many small motors. Practical experience showed that the reliability and availability with the large motors was low because such unavoidable accidents as the breaking of a single carbon might damage the commutator and keep the locomotive out of service. On the other hand a similar occurrence in the locomotives having many small motors, that is, sectionalized power, permitted quick replacement and much greater availability of the locomotives.

Another discussion by C. A. Butcher (New York, N. Y.) explained that heretofore he had not been an enthusiast for mercury arc power rectifiers but the advantages of the new development described in the paper and the indications, from extensive research laboratory work and testing, of a higher order of reliability have lead him for the first time to be enthusiastic about a rectifier.

W. E. Gutzwiller (Milwaukee, Wis.) also discussed this paper and it is his belief that the claims made for this rectifier were somewhat overemphasized. He pointed out that experience has shown that small sectional types have usually been later supplanted by large single-tank types for reason of simplicity and reliability except in very special cases where other considerations were dominant. This, he believes, is particularly true on fluctuating loads, such as heavy traction service where a real gain in reliability is of more importance than a slight gain in efficiency.

## Symposium on Time and Time Services

L. S. Harrison (New York, N. Y.) described a master clock system which hourly supervises the uniform agreement of electric secondary units. In this system the master clock, with a high-grade 60-beat pendulum regulator which is capable of rating within 2 to 3 sec. per month, transmits over an individual three-wire system its own accuracy to the secondary time pieces, both as to rate of advance and as to a point origin of time by means of a periodic time check. The system was introduced in 1924 and it has had wide application throughout the United States and Canada.

The inventions of Mathias Hipp, who was a pioneer in the art, were interestingly brought out by Herman Lemp (New York, N. Y.) in his discussion of this subject. It was explained that Mathias Hipp's electric clocks are known all over Europe. They have been in continuous service in the principal cities of Switzerland since about 1868 and furnish accurate time to a critical public, makers of Swiss watches and chronometers. This inventor was also the first to construct an astronomical pendulum of steel with mercury compensation.

J. D. Crawford (Cambridge A, Mass.) in his discussion of this subject referred to the series of experiments undertaken by the late Dr. A. A. Michelson. These experiments involved the determination of the time it took light to travel ten times between two sets of mirrors placed at the ends of an evacuated tube about a mile long. In making these measurements a crystal clock was used as the reference standard.

### Telegraph Time Service

In connection with this subject W. A. Dudley (New York, N. Y.) explained that usually one or more synchronized clocks in each office of the telegraph companies are provided with cam-operated contacts which, through suitable relays, are used for the control of timing and dating stamps. Thus these clocks, which are part of a synchronized time service described in the paper, provide an accurate means for controlling and checking the speed of service.

J. C. Wilcox (New York, N. Y.) also discussed this paper and referred to the movements, construction, and application of the subscribers' clocks. He pointed out that these clocks are independent operating units with the ability to operate continuously and accurately regardless of outside line interruptions. He explained that these self-winding clocks were found on every railroad and subway system in New York with the largest installation in the Grand Central Terminal where over 1,000 units are operated.

Another discussion by R. C. Thayer (St. Paul, Minn.) brought out the value of the noon beat signals as sent out by the two telegraph companies to the railroads of this country. These signals are redistributed throughout the railroad companies networks of communication circuits so that each of the railroad stations and train dispatchers receive the correct time daily.

SYNCHRONOUS ELECTRIC TIME SERVICE

This subject was discussed by Philip Sporn (New York, N. Y.) who believed that a reading of the paper was likely to give the wrong impression—that the question of frequency control by operators of large power systems was a simple matter, involving little more than the use of a master clock. Some of the difficulties involved in frequency regulation on an interconnected system were explained by the discusser and illustrated by load charts of a tie line which showed the wide fluctuations caused by close frequency regulation.

R. J. Wensley (Newark, N. J.) also discussed this subject and brought out that the first interest displayed by the central station industry in synchronous timekeeping was in the use of such methods for the integration of demand against definite time intervals. He also pointed out that at present the usual power system is not regulated with sufficient accuracy to permit the use of synchronous timing of extremely short intervals.

**The Bonbright Survey** of electric light and power companies of the United States, eighth edition, revised September 1931, recently was issued by the McGraw-Hill Publishing Company, Inc., of New York. According to the foreword in this volume the first edition of the survey was compiled in 1923 by Bonbright and Company, Inc., investment bankers closely identified with the electric power and light industry. Since January 1926, the publication has been compiled and issued by the McGraw-Hill company. In the present edition, corporate relationships and territories served are given as received until November 1931, in reports from the power companies concerned, while financial statistics are given, so far as was possible, as of June 30, 1931. The list of holding corporations and subsidiary companies has been revised; financial data have been augmented to include more of the municipal and smaller privately owned properties; listings of incorporated cities and towns having a population of not less than 2,500 have been augmented to include results of the 1930 census. The published price is $10 per copy.

**Successor to C. L. Edgar Appointed.**—Announcement has been made of the election of W. C. Baylies as president of the Edison Electric Illuminating Company of Boston, Mass., at a special meeting of its directors. He succeeds C. L. Edgar (A'96, F'12) who died suddenly April 14, 1932. Mr. Baylies graduated from Harvard in 1884, and previously was vice-president and chairman of the executive committee of the Edison Electric Illuminating Company.

## Forty Years of Manufacturing

At the annual meeting of the General Electric Company at Schenectady, N. Y., President Gerard Swope (A'99, F'22) cut a birthday cake in observance of the company's fortieth anniversary. In April 1892, the General Electric Company was formed by the consolidation of the Thomson-Houston and the Edison General Electric companies. The figure "40" composed of ornamental electric lights decorated the top of the cake.

## Southern California Utility Pioneer Dies

On the same day that the electric utility industry in the East lost one of its leaders of long standing through the death of C. L. Edgar of Boston, Mass. (see p. 359–360 this issue) a similar loss occurred on the Pacific Coast in the death of John Barnes Miller, chairman of the board of directors of the Southern California Edison Company, Ltd. Mr. Miller, who was 62 years of age, died on April 14, 1932, at Los Angeles, Calif.

After studying at the University of Michigan, Mr. Miller returned to his native city of Port Huron, Mich., in 1890, but after a few years' business experience there and in Louisana, went to California in 1896. In 1898 he was elected treasurer of the Edison Electric Company, later the Southern California Edison Company, becoming its president three years later. After being both president and chairman of the board for many years, he resigned the former position in 1928. He was also an officer and director in several other companies, and in 1925 was elected a vice-president of the National Electric Light Association.

Mr. Miller symbolized the pioneer spirit of the West, and under his direction many small companies were consolidated and reorganized into one company noted for its soundness as well as for its ease of operation. Teamwork among employees and customer ownership of stock were encouraged, much of the pioneer work in this latter activity having been done by Mr. Miller.

## A.S.M.E. to Hold Meetings

The sixth annual aeronautic meeting of The American Society of Mechanical Engineers will be held at the Hotel Statler, Buffalo, N. Y., June 6–8, 1932. The technical program will include some 30 papers and reports covering aerodynamics, navigation, engines, airplane carriers, design, and fuel. The technical sessions will be held on Monday and Tuesday, with Wednesday open for various plant inspection trips and a sightseeing tour around Niagara Falls.

At the same time, Buffalo will be host also to the first national process meeting of The American Society of Mechanical Engineers, with technical sessions on Monday and Tuesday, and the same trip to the Falls scheduled for Wednesday.

The American Society of Mechanical Engineers, with the cooperation of the Engineering Institute of Canada, will hold its 1932 spring meeting at Bigwin Inn, Lake of Bays, Ontario, Canada, June 27–July 1, 1932. This year the scope and magnitude of the meeting will be expanded and it is expected that it will include papers illustrative of British, Canadian, and American engineering practise.

Among the special trips available is a tour leaving New York, N. Y., on June 26 and Toronto, Ontario, Canada, on June 27. At the conclusion of the convention the trip will include seven additional days by boat and railroad through some of the most picturesque sections of Canada.

## Control of Foreign Investments

Because of its importance to citizens of this country who have investments abroad, and because of its close relation to the problem of investments in engineering projects undertaken within the limits of this country, the following editorial from the April 14, 1932, issue of *Engineering News-Record*, p. 533, is reprinted herewith in full:

### "Engineering Advice Needed"

"A service to the country generally has been done by the American Institute of Consulting Engineers in a statement addressed to the Senate finance committee giving pertinent facts concerning the investment of capital in Latin America. The

Senate finance committee has been investigating conditions surrounding the investment of funds from this country in foreign fields to determine why many investments so made have turned out to be a failure. It sought to learn where responsibility for this development lay. The Institute's (A.I.C.E.) report—prepared by engineers of long experience in Latin America—places responsibility squarely on the bankers for failure to get disinterested opinion on the soundness of the ventures they were financing and to set up proper checks upon the way money was spent.

"Money has been loaned to Latin American governments in the belief that it was to be used to construct useful public works without knowledge as to the need for or revenue-producing value of the proposed works, without stipulation that the money was to be spent only upon approved work, and without providing for proper control of its expenditures. As far back as 1919 the Institute (A.I.C.E.) began urging upon American bankers the desirability of universal adoption of a practise followed by most British bankers but by only a very few in America—namely, employing independent consultants to pass upon the feasibility of projects for which they have been asked to provide funds. If after investigation the project appears attractive, British bankers do not pass out the money without stipulating that they retain control over the manner in which it is spent, and usually even over the operation of the project when completed. A second time in 1923, again in 1928, and once again in 1929, the Institute (A.I.C.E.) urged the adoption of this practise upon the principal investment houses of this country. Their warnings went without effect.

"The bankers, it appears, saw only the Institute's (A.I.C.E.) selfish interest in urging engineering investigation and control and so ignored it, being content to take any bond issue that came along regardless of its merit so long as they could make a profit out of the underwriting, passing the bonds on to the trusting public which, in the end, 'holds the bag.' The folly of that practise is now all too obvious. Much of the money so invested has been squandered on ill-conceived undertakings, investors in this country have lost or stand to lose most or all of their principal, and confidence in the banking houses that sold them the bonds has been lost. Distrust of all Latin American investments has been developed. But worst of all, international distrust and ill-will have been built up just at a time when trust and good-will are most needed.

"A frank and convincing statement of what could have been done to protect American investments abroad, even though it comes from an interested party, cannot but help to insure the adoption of sound practises in the future. The Institute (A.I.C.E.) is to be congratulated for having risked arousing antagonism among bankers in order to put the facts clearly before the public."

# Letters to the Editor

## Heart Injury From Electric Shock

*To the Editor:*

I have read the Kouwenhoven article, "Heart Injury From Electric Shock," in the April 1932, issue of ELECTRICAL ENGINEERING, p. 242–4. Are we publishing an engineering journal or a medical journal devoted to vivisection?

I deplore the efforts of Doctor Kouwenhoven to link the American Institute of Electrical Engineers with vivisection and kindred surgical work. It is not our natural field and I do not believe the rank and file of our members approve of this excursion into territory so far removed from engineering.

Yours very truly,
F. G. STRONG (A'91, F'13 and Life Member) 120 Hartford Ave., Wethersfield, Conn.

## Nerve Injuries From Electric Shock

*To the Editor:*

I should like to commend ELECTRICAL ENGINEERING for the breadth of view shown in publishing the article "Nerve Injuries from Electric Shock," in the December 1931, issue, p. 929–32.

To me the article was of great interest and I welcomed it as being a genuine contribution toward the goal of resuscitating all who are so unfortunate as to receive violent electric shocks. The more not only members of the medical profession but also the laymen like ourselves know about the physiological effects of electricity, the more successful we are likely to be in reviving a person who has received an electric shock, in case, at any time we are confronted with such an emergency.

Very truly yours,
D. W. ROSEBRUGH (A'23, M'29)
(22 Baker St., Poughkeepsie, N. Y.)

## Suggested Changes in Dielectric Nomenclature

*To the Editor:*

In the study of dielectrics, the following names are suggested as being more logical than those now in use:

1. "Capacitance factor" is proposed to replace "dielectric constant."
2. "Loss factor" is given a slightly different meaning from that previously used.
3. "Capacitivity" is suggested to replace "permittivity" in systems of units where the latter quantity is now used.

There are always objections to changes in nomenclature, especially when such changes are suggested for names of concepts of long standing. Nevertheless our language is continually changing, so that suggestions for simpler or more logical terms should be encouraged and carefully considered in order that the best possible picture of a field of study will be conveyed by the nomenclature used.

From an experimental point of view an imperfect dielectric may be represented in terms of an equivalent parallel circuit of resistance and capacitance; in fact, most determinations of the a-c. properties of dielectrics employ bridge or substitution methods of measurement in which the characteristics of the sample are measured in terms of resistors having negligible distributed capacitance and capacitors having negligible loss in series or parallel combinations. The complex expression for the experimentally determined electrical properties of the dielectric is then

$$Y = G + i\,w\,C \tag{1}$$

where $G$, the equivalent parallel conductance, is a measure of the component of current in phase with the applied potential, and therefore of the total dielectric loss by whatever mechanism it may be produced. Also $C$, the equivalent parallel capacitance is a measure of the component of current in leading quadrature with the applied potential and therefore of the total charge stored per cycle per unit potential. From a theoretical point of view, Debye ("Polar Molecules," p. 94, The Chemical Catalogue Co., 1929) has used a set of symbols from which the expression corresponding to eq. 1 is

$$Y = i\,w\,C_v\,(\epsilon' - i\epsilon'')$$

which when expanded gives

$$Y = \epsilon''\,w\,C_v + i\,\epsilon'\,w\,C_v \tag{2}$$

In this relation two new names are suggested, namely, capacitance factor, $\epsilon'$, and loss factor, $\epsilon''$; the relation between them gives the well-known and generally used quantity

$$\text{Power factor} = \sin\,[\tan^{-1}(\epsilon''/\epsilon')] \tag{3}$$

The first named or capacitance factor is defined by the relation

$$\epsilon' = \frac{C_x}{C_v} \tag{4}$$

and is the ratio of the capacitance of the sample to the capitance of a vacuum space of the same size and shape. Generally this is called the specific inductive capacity or the dielectric constant of the material, but there are two objections to the latter name, which is most commonly used: First, $\epsilon'$ is not constant, but varies with temperature because of changes in density and with frequency if the sample contains polar molecules which can move in a viscous medium. Therefore it might better be called a coefficient or multiplying factor rather than a constant. Attention already has been called to this misuse of words by G. L. Addenbrooke (*Nature*, v. 126, Nov. 22, 1930, p. 808). Second, the word "dielectric" is general whereas the word "capacitance" specifically refers to the storage of charge or the component of current in leading quadrature with the applied potential. Therefore it seems that "capacitance factor" is more descriptive of the true meaning of the quantity $\epsilon'$.

The second of the two factors or loss factor, is defined in terms of experimental data by comparing eq. 1 and 2 from which

$$\epsilon'' = G/w\,C_v \tag{5}$$

In general, $\epsilon''$ is proportional to the loss per cycle per unit volume. It may be a function of all the experimental parameters, and in no way implies the mechanism or cause of the dielectric loss, of which it is a measure. There is precedence for the name "loss factor" ("A.S.T.M. Report of Committee D-9 on Electrical Insulation," 1931, p. 93), since it has been used to express the product of the dielectric constant and the power factor in per cent.

For small loss angles power factor = $G/\omega\epsilon' C$ so that by the A.S.T.M. definition the loss factor will be the same as given by eq. 5. For large loss angles, however, my definition will have a clearer physical meaning since $\epsilon''$ is taken to measure only the loss, independent of the capacitance, whereas the A.S.T.M. definition is influenced by the capacitance because power factor is defined exactly as the sine rather than the tangent of the loss angle.

Capacitance factor and loss factor are coefficients which vary as different functions of the experimental variables, and therefore a better understanding of the electrical properties of an insulating material can be obtained by studying each separately, than by studying power factor, which according to eq. 3 involves both. For example, according to Debye's theory of polar molecules, the variation of these two factors with frequency is given by the following relations (H. H. Race, *Phys. Rev.*, v. 37, Feb. 1931, p. 441):

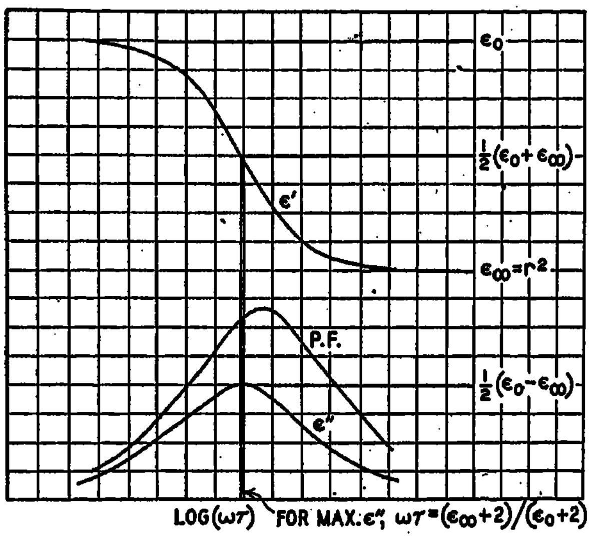
$$\epsilon' = \frac{\epsilon_0(\epsilon_\infty + 2)^2 + \omega^2\tau^2\epsilon_\infty(\epsilon_0 + 2)^2}{(\epsilon_\infty + 2)^2 + \omega^2\tau^2(\epsilon_0 + 2)^2} \qquad (6)$$

$$\epsilon'' = \frac{\omega\tau(\epsilon_0 - \epsilon_\infty)(\epsilon_\infty + 2)(\epsilon_0 + 2)}{(\epsilon_\infty + 2)^2 + \omega^2\tau^2(\epsilon_0 + 2)^2} \qquad (7)$$

where

$\epsilon'_0$ = capacitance factor at zero frequency
$\epsilon'_\infty$ = capacitance factor at infinite frequency
$\epsilon_\infty$ = (index of refraction)$^2$
$\tau$ = relaxation time

The above subscripts differ from those used by Debye and refer directly to the frequency at which the measurement is made.



Capacitance factor ($\epsilon'$), loss factor ($\epsilon''$), and power factor (P.F.) for a hypothetical polar liquid, using Debye's theory for case where $\epsilon_0/\epsilon_\infty = 2$.

To illustrate the variations of these three factors with frequency, the accompanying curves have been drawn for a hypothetical polar liquid in which $\epsilon_0 = 2\epsilon_\infty$. The power-factor curve is plotted to ten times the scale used for the other two, and illustrates the fact that this function is more complicated than $\epsilon''$ and that it is less difficult to determine the frequency for maximum loss factor than the frequency for maximum power factor as has been done by Whitehead (*Phil. Mag.*, v. 9, 1930, p. 865).

While I am discussing nomenclature for dielectrics, there is one more name which I should like to propose; the capacitance of a unit cube of dielectric is called its permittivity by some writers, but the name "capacitivity" seems much more appropriate. The word "permittance" is not in general use, while the word "capacitance" has been almost universally accepted. Therefore the capacitance per unit volume might better be called capacitivity. The accompanying table shows that this name is consistent with our present scheme of nomenclature:

| | | |
|---|---|---|
| Conductor | Resistor | Capacitor |
| Conductance | Resistance | Capacitance |
| Conductivity | Resistivity | Capacitivity |

Thus the capacitance of a homogeneous dielectric is given by the following relation

$$C = \epsilon' C_v = \epsilon'\epsilon_v(a/l) \qquad (8)$$

where $\epsilon_v$ = capacitivity of vacuum and $a$ and $l$ are, respectively, the effective area and length of the dielectric field. Thus the capacitivity of any dielectric is its capacitance factor multiplied by the capacitivity of vacuum; $\epsilon_v$ may be considered to be dimensionless and equal to unity or having both a dimensional formula and a numerical value, depending upon the system of units used. However, capacitance factor, loss factor, and power factor as defined are numerics in all systems of units.

Very truly yours,
Hubert H. Race (A'24)
(Research Engineer, General
Elec. Co., Schenectady, N. Y.)

# Engineering Foundation

## Personnel Research Federation Active

Toward meeting unemployment, the Personnel Research Federation, now over ten years old, has cooperated with agencies throughout the country by assembling and distributing information as to the methods of studying and dealing with employment. A conference was held jointly with the Social Science Research Council to determine the effects of part-time and lay-off on workers' efficiency and morale. Various other researches and investigations have been suggested and undertaken.

Continuing the investigation of causes and treatment of accident proneness on highways and in factories, a study has been made of accident susceptibility among 5,000 drivers over a 5-year period. In cooperation with the National Safety Council and other agencies, the Federation has undertaken to concentrate efforts on the diagnosis and cure of the relatively small proportion of the population who appear to be prone to accidents.

## Studies Made of Engineering Education

Studies of engineering education made by the education research committee of Engineering Foundation have been facilitated by cordial cooperation from coast to coast. Proposals for fundamental improvements are being examined by educational and engineering societies under the leadership of the Society for the Promotion of Engineering Education. Progress has been made on giving information to serve as a guide in the selection of a vocation.

A pioneer demonstration of another method was given by H. N. Davis, chairman of the committee and president of Stevens Institute of Technology. In August 1931, a camp for high school boys was conducted for two weeks, during which time simple examples of engineering and talks by different engineers were given, supplemented by a large variety of tests. The experiment was declared a success and is to be repeated in 1932.

The committee has given assistance also in the formulation of practical tests intended to appraise the qualifications of youths and men for various occupations. Other studies are receiving consideration and the committee is cooperating with the American Council on Education, and is continuing aid to the summer schools which are being conducted for engineering teachers by the Society for the Promotion of Engineering Education.

# American Engineering Council

## Pending Patent Legislation

Considerable legislation affecting the granting of patents and patent office procedure has been introduced into the present Congress. The views of American Engineering Council's patents committee have been given by its chairman, E. J. Prindle (A'06, M'20) to Congressman W. I. Sirovich, chairman of the committee on patents of the House of Representatives. Some of the more important bills, with the opinions transmitted by Mr. Prindle, are given below:

H. R. 10,152—To empower the assignees of inventor to file divisional, continuation, renewal, or reissue application. This bill is favored as an efficient simplification of procedure. The original bill has been superseded by H. R. 11,018, and slightly amended by the insertion of a clarifying phrase.

H. R. 10,153 superseded by H. R. 11,016—To limit the life of a patent to a term commencing with the date of application. Opposition to this bill was expressed because it does not give sufficient regard to the circumstances of the particular application for patents.

H. R. 10,154 superseded by H. R. 11,017—Permitting single signature in patent applications and validating joint patent for sole invention. This is considered a wise and constructive measure.

H. R. 10,155—To abolish the statute permitting renewal of patent applications. This bill was approved by Mr. Prindle, and the patents committee of the House has voted to report out the bill.

H. R. 10,156 superseded by H. R. 11,019—To limit inventors to priority of two years before filing application for patents. In effect this bill cuts down to a term substantially below two years the period in which the patentee might try out his invention on the market before applying for a patent. An extension of this limit to three years was suggested.

H. R. 10,157—To expedite prosecution of patent applications pending more than three years. This bill has been reported by the patents committee, and is supported by a special committee which carries very considerable weight and authority.

## Engineering Council Formed at Los Angeles

Local chapters of the four national engineering societies in Los Angeles, Calif., recently formed the "Los Angeles Engineering Council of Founders Societies." The preamble to its constitution is identical to that of American Engineering Council and reads: "The object of the Council shall be to further the public welfare wherever technical and engineering knowledge and experience are involved, and to consider and act upon matters of common concern to the engineering profession."

The executive committee is composed of Robert Linton, *president;* Carl Johnson (A'09, F'25), *vice-president;* L. W. Voorhees, *secretary-treasurer;* and A. F. Barnard. Among the other eight members of the council are two members of the Institute, A. P. Hill (A'23, M'29) and Prof. R. W. Sorenson (A'07, F'19).

## Muscle Shoals Bill Reported in House

A bill, No. 11,051, introduced by Representative Hill of Alabama, to provide for the leasing and other utilization of Muscle Shoals properties, in the interest of national defense and agriculture, was reported from the military affairs committee of the House of Representatives, April 4, 1932.

The measure is essentially different from the Norris bill in the Senate. It concerns all of the Government owned properties located at and near Muscle Shoals except the power plant and power generating facilities, and provides for a board of three authorized to lease and hold these properties for a period not exceeding 50 years from the date of enactment, and upon such terms and conditions as, in its judgment and subject to the limitations of the act, will best serve the interests of the United States in carrying out the purposes of this act.

**Spring Meeting of Administrative Board.**—Announcement has been made that the spring meeting of the administrative board of the American Engineering Council will be held May 13–14, 1932, at the Washington Hotel, Washington, D. C.

# Personal

W. G. Cady (M'19) professor of physics at Wesleyan University, Middletown, Conn., at a recent election of officers of the Institute of Radio Engineers was chosen to be its president. Doctor Cady is a native of Providence, R. I.; his Ph.B. degree was conferred upon him by Brown University in 1895; his A.M. the following year, and his Ph.D. was received from the University of Berlin, Germany, in 1900. For two years, he was magnetic observer of the United States Coast and Geodetic Survey, at Cheltenham, Md., the following year becoming instructor in physics at Wesleyan University, where for some time he has been in charge of all courses in electricity. His work in the piezoelectric field has been conspicuous and in 1928 resulted in his being awarded the Morris Liebmann memorial prize. This prize is an annual award made by the Institute of Radio Engineers and was made possible by a gift of $10,000 to perpetuate the memory of Col. Morris N. Liebmann, a communication engineer who lost his life in the World War; the annual accrual of interest upon this amount constitutes a cash prize of approximately $500, and the award is made for outstanding accomplishment in the field of communication. Doctor Cady has done some very important work in connection with the electric arc submarine signaling and the detection of vibrations due to feeble water disturbances. He also has contributed considerable of importance to research in both physics and electricity and has produced many valuable technical papers.

W. G. CADY

F. L. Rhodes (A'03, F'13) outside plant development engineer for the American Telephone and Telegraph Company, New York, N. Y., and through a term of service of over thirty years largely responsible for determining the present day standards of the company for outside plant construction, because of ill health retired from active service March 1932. Mr. Rhodes is a native of Boston, Mass., and obtained his B.S. degree from Massachusetts Institute of Technology in 1892. That year he entered the mechanical department of the American Bell Telephone Company of Boston and for several years was occupied chiefly with electrical measurement work relating to telephone transmission over open wire lines and cables; he also did work on the design and development of induction and repeating coils. In 1899 when the department was amalgamated with the engineering department of the American Telephone and Telegraph Company, Mr. Rhodes was chosen to specialize on the design and engineering of the outside plant of the telephone system, and in 1905 was placed in charge of the division of the engineering department responsible for the outside plant engineering. He was one of the principal members of the staff of Col. J. J. Carty. As liaison officer between the telephone companies and the electric light companies he accomplished much valuable work. He has been called upon to give expert testimony in legal cases both in the United States and Canada, and for three years served on the overhead line construction committee of the National Electric Light Association. Mr. Rhodes also has served the Institute on its board of examiners (1915–20), on its meetings and papers (now technical program) committee (1916–17), as chairman of the communication committee for a year besides serving as a member of the committee for three years; and for seven years he was a member of the standards committee.

K. B. McEachron (A'14, M'20) research engineer, L. H. Whitney (A'23) chemical engineer, and F. M. Clark (A'24) physicist, all of the General Electric Company, Pittsfield, Mass., and M. A. Savage (A'21) design engineer, and C. A. Nickle (A'25) an electrical engineer at the company's Schenectady works are participants with eighteen other General Electric employees in the 1932 award of the C. A. Coffin Foundation prize. This Foundation, established in 1922 to perpetuate the name of the founder and first president of the company, awards $11,000 annually for the most signal contributions by employees of the company toward increased efficiency or progress in the electrical art. No matter what the type of work, an employee is eligible for consideration for an award. With each prize is given a certificate of merit. Mr. McEachron received his award for outstanding accomplishment in the invention of Thyrite for use in lightning arresters; Mr. Whitney, for his valuable assistance to Mr. McEachron in this development; Mr. Clarke, for special contributions to the quality as well as reduction in cost, of capacitors; Mr. Savage, for unusual ability in the design and development of large steam driven generators; and Mr. Nickle for his exceptional ingenuity in the development of hysteresis motors of new and improved design.

J. F. Fairman (A'20, M'27) who for the past six years has been assistant electrical engineer for the Brooklyn Edison Company now has become electrical engineer for that company. His progress since joining the Brooklyn Edison Company in 1925 as assistant outside plant engineer has been marked, as was his advancement in his academic work on the teaching staff of the University of Michigan, from which he was graduated in 1918, and thereafter was first instructor and then assistant professor of electrical engineering. Following his discharge from military duty after the World War, he took the graduate student course of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., thereafter returning to the university for further teaching.

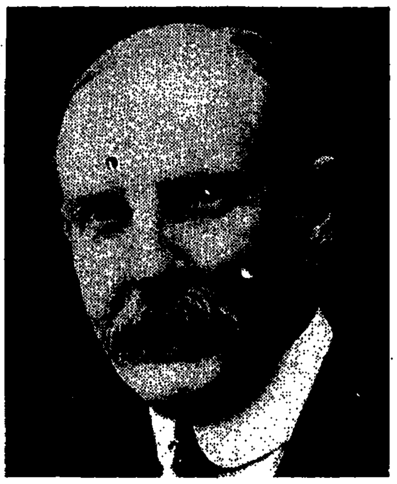
A. L. Nelson (A'16, F'29) who for twelve years has been a member of the firm of Jackson and Moreland, Boston, Mass., as well as manager of its construction department handling problems relating to plant investigation, operation, and construction, now has established a business of his own under the firm name of Arthur L. Nelson Engineers, for the same type of work as before. Mr. Nelson has served several of the engineering groups on committee work, including the A.I.E.E., A.S.M.E., N.E.L.A., and the Boston Society of Civil Engineers of all of which he is a member. From 1920 to 1924 he was on the faculty of the Massachusetts Institute of Technology, electrical engineering department, and gave lectures on power plant design, construction, and operation.

C. L. Law (A'20) general commercial manager of the New York Edison Company, New York, N. Y., now fills a similar position with the United Electric Light and Power Company, of New York. He has been with the Edison company since 1906 in various managerial capacities and received his appointment as general commercial manager in 1929. Only recently he was elected president of the Electrical Association of New York, and through his membership in other representative bodies including the American Association for the Advancement of Science, has been actively executive.

J. R. North (A'21, M'29) who has been assistant investigations engineer for the electrical engineering department of the Allied Engineers, Inc., Jackson, Mich., now has become general engineer of the Commonwealth and Southern Corporation, also at Jackson. Mr. North is serving on the foreign systems coordination committee (national) and various project committees of the joint subcommittee on development and research of the National Electric Light Association and the Bell System.

N. E. Wunderlich (A'27) engineering executive for the R. C. A. Victor Company, Incorporated, at Camden, N. J., recently established a new system for improved radio reception. This system, which bears the name of its inventor and was exhibited with success at the Chicago radio show, consists of a special yet simple circuit and a new type of tube serving the three-fold purpose of detection, amplification, and automatic volume control. Preliminary tests and measurements by two nationally recognized laboratories confirm its claims.

A. E. Kennelly (A'88, F'13, and past-president) professor emeritus of electrical engineering of both Harvard University and Massachusetts Institute of Technology, on the evening of Friday, April 8, 1932, was the recipient of another distinction in the bestowal of the Medal of Honor of the Institute of Radio Engineers, of which he is a past-president. Doctor Kennelly's achievements have been so numerous and so well known that they will not be included here. This latest citation was "for his studies of radio propagation phenomena and his contributions to the theory and measurement methods in the a-c. field which now have extensive radio application." The award itself includes a gold medal suitably engraved and bestowed annually upon "that person who has made public the greatest advance in the science or art of radio communication, regardless of the time of performance or publication of the work on which the award is based." Others who have received this Medal of Honor include Guglielmo Marconi (HM'17) M. I. Pupin (A'90, F'15, HM'28 and past-president) J. S. Stone (A'08) E. F. W. Alexanderson (A'04, F'20) Lee DeForest (A'04, F'18) and others, the first award having been made in 1918.


A. E. KENNELLY

W. I. Middleton (A'09, M'14) who has been chief electrical engineer of the Simplex Wire and Cable Company for many years, now has retired from office, completing a record of distinction. He has made many valuable original contributions to cable production and application. Mr. Middleton's connection with the company dates from 1903; his work in the cable field includes the pioneering of deep oil well cable and the all rubber covered cable design for mining service. His reputation in cable engineering is world wide.

H. V. Bozell (A'08, F'23) who has been identified for some time with Bonbright and Company, New York, N. Y., and who at one time was editor of the *Electrical World*, now has been elected executive vice-president and a member of the board of directors of the Associated Telephone Utilities Company, a holding company which through its subsidiaries operates some 909 exchanges over properties including 511,000 telephones and about 60,000 miles of toll line in 25 states of the Union.

C. R. Beardsley (A'08, F'30) has been appointed assistant to the superintendent of distribution of the Brooklyn Edison Company, Brooklyn, N. Y. Since 1923 he has been electrical construction engineer and had the supervision of the electrical construction of the Hudson Avenue power station and of substations. Also from 1928 to 1930 he was chairman of the accident prevention committee of the engineering national section of the National Electric Light Association.

F. L. Aime (A'15) an electrical engineer for the J. G. White Management Corporation, New York, N. Y., and for many years identified with the Utility Management Corporation, New York, N. Y., recently joined the staff of the consulting engineers, Gibbs and Hill, also of New York. Specifically, his new operations will include assignment to high voltage cable work in connection with the electrification which his company has undertaken for the Pennsylvania Railroad.

A. J. Gowan (A'23) now has been engaged as electrical engineer of the U. S. Army Engineer Corps., Rock Island, Ill., in charge of electrical design and installation of locks and dams in connection with the Nine-Foot Channel development on a section of the Mississippi River. He has served as an electrical engineer with the General Electric Company, Stone and Webster Engineering Corporation, and Atmospheric Nitrogen Corporation.

W. C. Mainwaring (A'22) for the past fourteen years district sales manager of the Northern Electric Company, Limited, Vancouver, B.C., has been chosen to head the merchandising activities of the British Columbia Electric Railway Company, Limited, both on the mainland and on Vancouver Island. He will bear the title of merchandising manager, a new position created by the recent rapid expansion of this department.

R. W. Shoemaker (A'07, M'19) who was at one time electrical engineer and superintendent of the electrical department of the Turlock Irrigation District, California, and more recently engaged by the Electric Bond and Share Company at Rio de Janeiro, now after a two years' stay in Brazil has returned to California to resume professional practise.

N. L. Towle (A'20, M'24) who has been assistant professor in charge of electrical laboratories at Cooper Union, New York, N. Y., now has been given charge of that institute's department of electrical engineering, with the rank of full professor

Professor Towle who has been on the staff since 1920 previously taught in the Iowa State College at Ames, Ia.

O. H. Caldwell (A'13, M'22) editor of "electronics" and "Radio Retailing," issued by the McGraw-Hill Publishing Company, New York, N. Y., and E. L. Nelson (A'20, M'26) radio development engineer at the Bell Telephone Laboratories, Incorporated, New York, N. Y., have been elected directors of the Institute of Radio Engineers to serve for the year 1932.

A. T. Perkins (M'25) president and general manager of the People's Motor Bus Company recently was elected to a two-year term of service as a member of the board of directors of the St. Louis (Mo.) Chamber of Commerce. E. B. Meissner (A'16) president and general manager of the St. Louis Car Company, also has been elected a member of its executive committee.

A. G. Richardson (A'24) who for two years was chief engineer of the Allen Hough Carryola Company, Milwaukee, Wis., and for a year after severing connections with that company, remained in Milwaukee to do experimental work for himself, using the Allen Hough laboratory, returned to New York, N. Y., December 1, 1931, to engage in radio service.

G. F. Sanderson (A'30) who has been doing engineering work for the Metropolitan Edison Company, Reading, Pa., now has become general manager for the West-Lon Light and Power Company, the Allied Vermont Utilities Company, and the Weybridge Light and Power Company, subsidiaries of the Colonial Utilities Corporation, Chester, Vermont.

E. B. Freeman (A'21) vice-president and general manager of the B. F. Sturtevant Company, Hyde Park, Boston, Mass., has been elected president succeeding former Governor Eugene N. Foss, who has been made chairman of the board of directors. Mr. Freeman's rise in the organization was from the sales engineering department.

W. J. Ducey (A'22, M'30) who was assistant electrical engineer for Allied Engineers, Inc., Jackson, Mich., now has been made the electrical engineer of Consumers Power Company at Jackson. Mr. Ducey is chairman of the overhead systems committee of the Great Lakes division of the National Electric Light Association.

S. S. Green (A'20) secretary-treasurer of the Duncan Electric Manufacturing Company, Lafayette, Ind., has been appointed chief engineer to succeed the late Jesse Harris (M'27). Mr. Green has been on the engineering staff of the company since 1929, when he first became identified with the Duncan organization.

G. J. Newton (A'10, M'15) who has been doing consulting work at Hollywood, Calif., now has removed to Youngstown, Ohio, to practise consulting distribution engineering there. Between 1916 and 1924 Mr. Newton served the Institute's power transmission and distribution committee for four terms.

R. D. McManigal (A'18) who has been serving the Westinghouse Electric Company of Japan at Tokyo as its special representative, now has been made assistant to the manager of the central station and transportation division of the Westinghouse Electric International Company, New York, N. Y.

Sidney Hosmer (A'97, F'12) who recently was made vice-president and assistant general manager of the Edison Electric Illuminating Company of Boston, Mass., now has been elected a director of the company to replace Robert Saltonstall, resigned.

R. E. Doane (M'25) who until recently was manager of the price and cost department of the Standard Underground Cable Company division of the General Cable Corporation, now has become sales engineer of the Doane and Jones Company, at Elmira, N. Y.

A. A. Leeven (A'24, M'30) superintendent of the electrical engineering department of Cia Hidroelectric Guanajuatense, S. A., in Mexico City, Mexico, was appointed division engineer of Cia Nacional de Electricidad, S. A., Torreon, Coahuila, Mexico, effective April 1, 1932.

Teruyoshi Matsuo (A'30) imperial inspector of the Japanese Navy, who has been in New York, N. Y., doing work for his government, now has returned to Japan, where he has been engaged in the capacity of electrical engineer for the Kure Kaigunkosyo Denki-Jikkenbu, at Hiroshima.

R. T. Bauschman (A'28) who was power sales engineer of the Pennsylvania Power and Light Company at Hazleton, Pa., recently was transferred to the statistical division, system operating department of that company.

M. W. Kellerman (A'29) formerly assistant general foreman of the Appalachian Electric Power Company at Welch, W. Va., now has been made rural extension engineer for the same company at Pulaski, Va.

W. S. Rollo (A'25) who has been doing engineering service for the Otis Elevator Company's Yonkers (N. Y.) works recently became connected with an English company, the Waygood Works, Ltd., in London.

Samuel Reber (A'93, F'12, and a Member for Life) general foreign representative of the Radio Corporation of America, New York, N. Y., recently was elected a director of the American-Russian Chamber of Commerce.

Emerick Toth (A'29) has left the Kolster Radio Corporation, Newark, N. J., where he was a laboratory assistant, and is now receiver engineer on high frequency circuits for Wired Radio, Incorporated, of Ampere, N. J.

J. P. Edwards (A'92, M'13) recently retired from the office of Eastern division traffic superintendent of the Western Union Telegraph Company. His term of service covered a period of some twenty years.

C. D. Taylor (M'20) who has been manager of the refrigeration department of Westinghouse Electric and Manufacturing Company, Mansfield, Ohio, now is vice-president and general manager of The Elin Company, at Philadelphia, Pa.

C. B. O'Neil (A'29) previously sales engineer for Fairbanks, Morse and Company, at Houston, Texas, now has been transferred to St. Louis, Mo., where he will be district manager of railroad sales for his company.

A. A. Armer (A'27) development engineer for the Magnavox Company, Ltd., Berkeley, Calif., now has been appointed field engineer for this company. His headquarters will be at Fort Wayne, Indiana.

T. H. Chen (A'29) who has been doing postgraduate student work at Cornell University, Ithaca, N. Y., now has returned to China where he will be identified with the Nanchang Electric Company, Nanchang, Kiangsi, China.

J. N. Barrett (A'21) in the past sales engineer for the Otis Elevator Company in the Detroit, Mich., district, now has been transferred to the company's offices at Washington, D. C.

F. I. Degen (M'24) who has been practising engineering in New York, N. Y., now has been elected vice-president of the Babcock Manufacturing Company, Leonardsville, N. Y.

R. W. Gaskins (A'24) formerly serving the Stone and Webster Engineering Corporation as engineer, has removed from Boston to join the Troy Laundry Machinery Company, East Moline, Ill.

K. Hirose (A'23) designing engineer for Shibaura Engineering Works, Kanasugi, Shibaku, Tokyo, Japan, now has been transferred by his company to Tsurumi, Yokohama City, Japan.

F. I. Morgan (A'31) who has been with the Pennsylvania Water and Power Company at Holtwood, Pa., now has affiliated himself with the Safe Harbor Water Power Corporation at Safe Harbor, Pa.

E. A. Mellinger (A'08) director of the Automatic Telephone and Telegraph Company, Chicago, Ill., recently resigned from his position on its board.

C. E. Chatfield (A'06, M'25) has resigned from the position of Chicago manager of the Lapp Insulator Company to form a sales agency at Indianapolis, Ind.

H. H. Hansson (A'29) electrical engineer for Sargent and Lundy, Inc., Chicago, Ill., now has engaged in like capacity with Motala Ström Kraft A. B., Motala, Sweden.

# Obituary

Bernard Arthur Behrend (A'00, F'12) internationally noted as an engineer and for his inventive genius, met with sudden death March 25, 1932, at his home in Wellesley, Massachusetts. He was born in Villeneuve, Switzerland, May 9, 1875, and as a boy resided in Switzerland, England, and Germany, receiving his early education by private tutelage, and through a course in the Polytechnic Institute and University of Berlin, Germany, from which he was graduated in 1894 with a C.E. degree. During the year following he was assistant to the late Gisbert Kapp, and in 1896 he became assistant chief engineer to the Oerlikon Company, Switzerland. This was immediately prior to his coming to the United States. He at once applied for citizenship and was granted naturalization in 1903. He has been non-resident lecturer at the University of Wisconsin, Leland Stanford University, McGill, and Massachusetts Institute of Technology. In 1899 he connected with the Bullock Electric Manufacturing Company, Cincinnati, Ohio, as chief engineer of its a-c. work, this office being subsequently extended to include all of the company's plants in both the United States and Canada. In 1904 the Bullock Electric company became allied with the Allis-Chalmers Manufacturing Company, Mr. Behrend continuing in the office of chief engineer of electrical departments in this company; he also established the first department in Milwaukee for the production of large units. At the end of 1908 receivers of the Westinghouse Electric and Manufacturing Company engaged Mr. Behrend and members of his staff to take charge of the power engineering departments at East Pittsburgh, Pa.; here he remained for 18 years, although devoting a large portion of his time to consulting work in Boston, Mass. Mr. Behrend has always been a prolific contributor to technical literature; his first outstanding work, "Theory of the Induction Motor (Circle Diagram)" produced between 1894 and 1896, represented one of the earliest expositions on a theory now universally applied, and used today in practically the same form in which he gave it over 36 years ago. It was chiefly the subject of his university lectures, and was published later in book form under the title "The Induction Motor," translations appearing in French, German, and some sections, even in Japanese. In 1897 he developed the theory of the regulation of alternators under inductive loads, urging its adoption for purposes of standardization. This was adopted in general as first proposed by him, although sometimes known under the name of "Potier" method; a paper before the Institute described the method in detail and recommended its standardization. Among others of his contributions are many Institute papers. In 1902 Mr. Behrend introduced the radial-slot cylindrical turbo-generator rotor with chrome nickel end rings. This unit was exhibited jointly at the World's Fair in 1904 by the Bullock Company and Hoovens, Owen, and Rentschler; it won the grand prize and Mr. Behrend was the recipient of the accompanying gold medal. The largest power unit of the exposition was a 3,500-kw. generator driven by an Allis-Chalmers engine, a product of Mr. Behrend's inventive ability. Between 1900 and 1908 he designed the electric generating units for the Kern River Power Company, the Pacific Electric Company, the Denver Gas and Electric Company, a large group of the Niagara Falls units, the receiving plant of frequency changing units at Montreal linking the Shawinigan Water and Power Company with the power plants at Montreal, the steam turbine units of the Brooklyn Edison Company and the Brooklyn Rapid Transit Company (at that time the fastest of their type). The large gas engine driven units of the Carnegie Steel Company, the Illinois Steel Company, and of the Indiana Steel Company were all of his design. In 1909 he introduced the radial slot rotor to the Westinghouse company and developed the plate rotor construction now used by the company for its largest types of turbo-generator rotors. It was a revolutionary type devised for the purpose of overcoming defects in large forgings. While engaged with the Allis-Chalmers and Westinghouse companies, Mr. Behrend took out over 80 patents. Devoted to the interest of engineering education, he organized under A. G. Wessling the first engineering training classes at Cincinnati, Ohio. He has served on many technical committees, among them the Institute's standards committee, the U. S. national committee of the International Electrotechnical Commission, the Engineering Societies Library Board, and the Edison Medal committee; he was chairman of the Institute committee on professional conduct, and electrical machinery, and was first chairman of the A.I.E.E. Section in Cincinnati. His service as a manager and senior vice-president of the Institute was over a period of five years. In 1912, for improvements on high-speed electric generators, he received the John Scott Medal; he was a member of the A.S.M.E. and the A.S.C.E. and of the Franklin Institute; a fellow of the American Physical Society, the American Society for the Advancement of Science, and the American Academy of Arts and Sciences, and a member of the Engineers' Club of New York.

Charles Leavitt Edgar (A'96, F'12) president and general manager of the Edison Electric Illuminating Company of Boston, Mass., died of pneumonia April 14, 1932, at the Marlborough Blenheim Hotel, Atlantic City, N. J. Mr. Edgar, who was in his seventy-second year, was a native of Somerset County, New Jersey. He was graduated in 1882 from Rutgers College, New Brunswick, N. J., receiving at that time the two degrees of A.B. and A.M.; his honorary degree in E.E. was received subsequently for postgraduate work at the same institution. The year following his graduation he connected with the Edison Machine Works in New York, N. Y., for nine months; then was transferred to the factory of the Bergman Company, which manufactured central station apparatus. Shortly thereafter he became connected with the Edison Electric Light Company at its original factory in New York, N. Y. This service continued until 1887, by which time he had advanced to the position of chief engineer. Most of his work had been of a general engineering character with particular reference to the installation of small central stations throughout New York and adjoining states. In the fall of the year 1887 the parent Edison company sent Mr. Edgar to Boston as superintendent of the Edison Electric Illuminating Company of Boston, which had been organized the year before; in 1889 he became general manager and shortly thereafter vice-president; and upon the death of Jacob Rogers in 1900 he was chosen president. The central station industry in this country owes much of its pioneer work to Mr. Edgar who toiled with diligent devotion to make its influence far reaching. He has made numerous trips to Europe to study first hand the methods used in the largest electric plants there, and as a result of these investigations he was among the first to appreciate the value of storage batteries as central station auxiliaries; in fact it was he who imported from Germany the Tudor battery, the first to be used in this service in this country. He also foresaw the importance of compact generating units for stations in congested districts, and installed at Boston the first vertical engines used in America for central station work. On a special visit to England in 1898 he studied the Wright demand system of charging and upon his return introduced this into the service of the Boston company. One of the features that has contributed great success to this company is its highly developed welfare work; Mr. Edgar interested himself personally in the formation of the Edison Employees' Club which gave so much impetus to similarly organized groups and later, to company sections of the National Electric Light Association in other cities. The Boston club has served as a model for many others. After being three times vice-president of the National Electric Light Association he was elected its president in 1903. He has been president of the Massachusetts Electric Light Association, at one time was chairman of the A.I.E.E. Section in Boston, and has served the Institute on the Edison Medal committee. Always a keen student of sociology and political economy in connection with modern industry, of recent years he has devoted much of his time to the affairs of the National Civic Federation, serving as a member of its committee of twenty-four, investigating the question of municipal ownership of public utilities in other countries. He also was chairman of the industrial welfare department of the federation for several years, in which work he made several surveys of the problem of old-age dependency and pensions. At the time of his death he was chairman of the board of the New England Power Association; a member of the executive committee of the Employers' Liability Assurance Corporation, Ltd.; director of the Employers' Fire Insurance Company of Boston, and of the Electrical Testing Laboratories of New York; and a trustee of the Massachusetts Utilities Associates Employers' Group Associates, and of Rutgers College, from which he received his Doctor of Science degree in 1927. He is a past-president of the Edison Pioneers and a member of Illuminating Engineering Society, The American Society of Mechanical Engineers, the Society for Electrical Development; also of the Exchange, Country, Algonquin, and University clubs of Boston, and the Engineers and University clubs of New York.

**Francis M. Hartmann** (A'02, F'14) dean of the school of engineering, Cooper Union Institute of Technology, New York, N. Y., and head of its electrical engineering department, died at his home March 28, 1932, as the result of complications which followed an operation. Dean Hartmann was born August 31, 1870, at Cochecton, New York. He attended Damascus Academy, in Pennsylvania, and New York evening high school. His B.S. degree was granted him upon the completion of a five-year course in general science at Cooper Union night school, New York, N. Y., in 1895; eight years later, by postgraduate work in physics and electrical engineering, he earned his E.E. degree. In the interim, however, he was graduated from a three-year course in chemical analysis, also taken at the Cooper Union night school, and had taken postgraduate work in physics and electrical engineering and other postgraduate work in mathematics at New York University. From 1891 to 1894 he was engaged in surveying and engineering with H. H. Spindler, for the City of New York, and from that time until 1901, Mr. Hartmann was computer in the city department of public improvement. Then he received his appointment as instructor in physics and electrical and mechanical engineering at Cooper Union for both day and night school, a position which he occupied until in 1905 he was made assistant professor of electrical and mechanical engineering, three years later to be placed in charge of the department. Paralleling a portion of this period he was working with A. G. Koenig, consulting engineer of New York; also with the E. E. Cary Company. In 1908 Cooper Union chose him chairman of the committee on promotion for three science courses; a five-year night school course in electrical engineering, a five-year night school course in general science and the day school technical science course. Dean Hartmann's contributions to technical literature have covered a variety of subjects. In 1912 he designed and equipped the new dynamo laboratories and thermodynamic laboratory for the Hewitt Memorial Building, Cooper Union. In addition to his membership in the Institute he was a Fellow of the American Association for the Advancement of Science, a member of The American Society of Mechanical Engineers, the American Physical Society, the American Mathematical Society, and the Society for the Promotion of Engineering Education.

**D. A. Wadia** (A'21) who for some time has been identified with the engineering branch of the Burma Shell Oil Storage and Distributing Company of India, Limited, St. Helen's Court, Ballard Estate, Fort Bombay, India, died at Surat on the 13th of January 1932. Of late he has been making his home with his uncle at Dadar. Mr. Wadia was a native of Bombay (1887); he held a scholarship from the Victoria Jubilee Technical Institute at Bombay, which allowed him to matriculate at the Bombay University. In 1908 he received the Victoria Jubilee Technical Institute first-class certificate with the degree of licensed mechanical engineer; he also held a certificate from the City and Guilds London Institute, department of technology, in the preliminary grade of electrical engineering, and a certificate for competency for what is there known as the Bombay Boiler Act, issued by the government. During his student days at the Victoria Jubilee Technical Institute, Mr. Wadia worked upon the erection of the institute's central power station, and prior to undertaking wiring installations for the Fazulbhoy Mills, Limited, he worked for eight months on a similar installation for D. R. Cooper and Company. As second assistant engineer, he joined the Brush Engineering Company of England, and was engaged by it in work upon the power house of the Bombay Electric Supply and Tramways Company. Another year was spent as electric foreman of the Simplex Conduits Limited. Engaged with the Tata Hydroelectric and Power Supply Company, Bombay, Mr. Wadia worked for three years upon the erection of substations. From 1914 to 1915 he was electrical supervisor for the Bombay Government Public Works Department, and for the next two years he was engaged with the Tata Hydroelectric Company as mill inspector in charge of electrically driven mills. In 1917 he entered the military works service at Karachi, assuming charge of all electrical and mechanical work in connection with machinery and shipments, erecting and maintaining the electrical installation connected with the Karachi concentration and rest camps. He also had charge of a 3-ton ice plant, both in its erection and maintenance.

**Brace Hayden Hamilton** (M'22) manager of the Washington, D. C., office of the Westinghouse Electric and Manufacturing Company, died March 21, 1932, in that city. He was born in Buffalo, N. Y., May 19, 1877, and after graduation from Cornell University with the class of 1899, he joined the General Electric Company for work on the design of d-c. and a-c. motors and generators. From 1902 to 1908 he specialized on turbo-generators and was involved in the supervision of special tools and methods essential to the construction of high speed apparatus. He also developed special designs and applications of governors and lubrication devices for turbines. Mr. Hamilton left the General Electric Company in 1909 to engage with the power division of the Westinghouse Electric and Manufacturing Co., Washington, D. C., on similar work in the design of d-c. and a-c. turbo-generators of the engine and water-wheel types. From 1910 to 1920 he worked on the design of power projects and the application of all types of power apparatus for the United States government, including the design of several complete plants. In 1917 he submitted a report to the chief of engineers, U.S.A., on the Potomac River hydroelectric development; this work was combined with laboratory experimental fixation of atmospheric nitrogen and with a study of an additional water supply for the District of Columbia. The year 1920 found him doing engineering work on generation and distribution of power from Wilson Dam, Muscle Shoals. For four years from 1917 to 1921, work on geared, electric and Diesel-electric marine drive, and auxiliaries for Navy vessels and the Merchant Marine occupied him; in fact as early in his career as when he was with the General Electric Company, Mr. Hamilton was responsible for the turbine design of horizontal turbo-generator sets for ships use.

**Jesse Harris** (M'27) who has been engineer in charge of development for the Duncan Electric Company, Lafayette, Ind., died February 15, 1932. He was born in Albany, N. Y., March 10, 1864; his schooling, the equivalent of a college education was supplemented by technical study. During the year 1888 he was engaged in general electrical contracting in Albany, and two years later entered the experimental department of the Thomson-Houston Electric Company at Lynn, Mass. In a year's time he had advanced to the position of assistant foreman of the meter department, thereafter becoming foreman of the instrument department. Returning to Albany, he was electrical engineer and superintendent of the Federal Instrument Company, and later electrical engineer of the Dongan Instrument Company. In 1907 he went to Lafayette, Ind., to develop recording instruments for the Central Laboratory Supply Company and the following year he joined the Duncan Electric Company, with which he remained for ten years as superintendent and fifteen years as chief development engineer on a-c. and d-c. meter development. Mr. Harris held twenty or more patents on various metering devices, one on a synchronous induction motor and another on a special system for operating a-c. motors from d-c. sources. He was considered a master technician in his line and did much excellent work in the correction of temperature errors in watthour meters. While with the Duncan company he was responsible for most of its design and development work.

**Thomas Foulkes** (A'08, M'13) founder of the Foulkes Electrical Company, Los Angeles, Calif., and a man who accomplished much of the pioneer work of the West in electrical engineering, died March 14, 1932, at the age of 80. He was born in England, receiving his early education in the common schools and partly at night school. He started his electrical work in the early days of the industry with the Citizens Electric Light Company, at Helena, Montana; then he spent a year with the Edison Company at Tacoma, Washington, a year with the Thomson-Houston Company, at Portland, working on the installation of isolated plants, and afterward some time with the General Electric Company. He was manager of the Baker City Electrical Light Company, Ore., engineer of the Hill House Hotel at Tacoma, Wash., and chief engineer of the Portland Hotel at Portland, Ore. He later went to southern California where in 1894 he became chief engineer of the municipal electrical plant at Pasadena. Two years later he bought an electrical business in that city, and in 1897 opened an electrical supply business in Los Angeles with a factory at Naud Junction. The factory was discontinued in 1899, and from then on the activities of the Foulkes Electrical Company were devoted exclusively to electrical engineering, design, and installation. Mr Foulkes was the first president of the Los Angeles board of public utilities.

Max Neuber (A'08, M'31) experimental engineer of the Moto Meter Gauge and Equipment Company, Toledo, Ohio, and secretary-treasurer of the Institute's Toledo Section, died April 4, 1932, at his home in that city. Mr. Neuber was born in Leipzig, Germany, and came to this country in 1889, his education including two years' schooling in Germany and six years in the public schools of Toledo, Ohio. He started to work in the factory in which his father was machinist, attending night school at the Toledo manual training school; he took up mechanical drawing and machine work also. This was followed by a correspondence course in mechanical and electrical engineering. By the time he had been in business eleven years he was operating machine works which involved a number of his own inventions, including an electric button machine and a water filtration system. Mr. Neuber leaves behind him a record of loyal service to the A.I.E.E. Section of which he was an officer, as well as an appreciation of the spirit of fellowship with which he inspired his many friends.

Marvin C. Ansteth (A'30) assistant superintendent of the western division of the Niagara, Lockport, and Ontario Power Company, Lockport, N. Y., died April 1, 1932 at Lockport. He was 36 years old and was born in Buffalo, N. Y., where he passed through elementary school and three years of technical high school. In 1915 he engaged with the Westinghouse Electric and Manufacturing Company at Buffalo, and two years later joined the Niagara, Lockport and Ontario Power Company as assistant superintendent of its Lockport-Mortimer districts. His affiliation with this company represented an uninterrupted period of service.

# Local Meetings

## Student Convention at Haverford College

The eighth annual local student convention sponsored by the Philadelphia and Lehigh Valley Sections was held at Haverford College on March 14, 1923, with eight schools participating: namely, Delaware, Drexel, Haverford, Lafayette, Lehigh, Pennsylvania, Princeton, and Swarthmore. The program of the morning session was as follows:

Thyrite Lightning Arresters, by Albert Werner, Drexel Inst.

Ship Stabilizing Devices, by W. J. Henderson, Jr., Univ. of Pa.

Solving Polyphase Problems by Symmetrical Components, by W. M. Dudley, Swarthmore Col.

Electricity in Aviation, by L. F. Underwood, Lehigh Univ.

Those attending the convention were guests of Haverford College at luncheon, afterward separating into groups, according to preference, to visit the Plymouth Meeting substation of the Philadelphia Elec. Co., high speed electric railway of the Philadelphia & Western RR. Co., Wayne Junction substation, Bell Telephone Co., and RCA Victor Co. Following dinner at the Engineers Club, Dr. W. E. Wickenden, president, Case School of Applied Science, gave an address entitled "The Engineer's Professional Status." The registration was 150.

## Future Section Meetings

**Akron**

May 10—Annual banquet and ladies' night. Human Engineering, by Dean Fred E. Ayer, Univ. of Akron. Movies.

**Baltimore**

May 20—Speaker: Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres. A.I.E.E.

**Cleveland**

May 19—Subject and speaker to be announced.

**Detroit-Ann Arbor**

May 17—House of Magic, by Oliver Ajer, Genl. Elec. Co.

June 21—Spring frolic.

**Lehigh Valley**

May 13—High Voltage Cables, by D. M. Simmons, Genl. Cable Corp. Meeting to be held at Americus Hotel, Allentown, preceded by dinner.

**Louisville**

May 13—Dial Telephone Equipment in Louisville. Speaker from the Southern Bell Tel. & Tel. Co.

June 3—Recreation meeting.

**Pittsburgh**

May 10—Annual banquet and ladies' night.

**Seattle**

May 17—Address by L. Sapovi, Hooker Electro-Chem. Co.

**Spokane**

May 27—Annual dinner meeting. History of the Electrical Development of the Inland Empire, by John B. Fisken. Election of officers.

**Vancouver**

May 21—Annual outing to the Baker River Plant of the Puget Sound Pwr. & Lt. Co.

June 6—Annual dinner.

## Past Section Meetings

**Baltimore**

Some Features of Interest in Motor Driven Water Pumping Stations, by Leon Small, water engr., City of Baltimore. Dinner. Feb. 19. Att. 74.

The Naval Engineering Experiment Station, by Capt. H. R. Greenlee, director. Inspection trip through the naval station. March 18. Att. 72.

**Boston**

The Osage River Development, by A. A. Northrop, H. B. Wood, H. O. Murphy, all of Stone & Webster Engg. Corp. Motion pictures. Feb. 16. Att. 205.

Short Time Phenomena With Relation to Recent Developments in Circuit Interruption, by Joseph Slepian, Westinghouse Elec. & Mfg. Co. Films—"Pole-Pushers in Puget Sound" and "The Magic of Communication." March 8. Att. 165.

**Chicago**

The Electrical Industry of Today, by C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Joint meeting with Western Soc. of Engrs. March 25. Att. 108.

**Cincinnati**

Steel Research in Electrical Manufacturing, by J. Fletcher Harper, Allis-Chalmers Co. Dinner. March 10. Att. 60.

Electrons at Work and Play, by Phillips Thomas, Westinghouse Elec. & Mfg. Co. Demonstrations. Joint meeting with Engrs. Club of Dayton. April 7. Att. 300.

**Cleveland**

Non-destructive Magnetic Testing of Ferrous Materials, by J. Kacmarik, Jr., student; The Practical Significance of Dielectric Power Factor, by R. W. Schindler, student; Ether Drift and Relativity, by Dr. Daynton C. Miller. Joint meeting with Case Sch. of App. Science Branch. March 24. Att. 199.

**Columbus**

Engineering in the Foreign Field, by H. W. Bibber, Ohio State Univ. Joint meeting with Engrs. Club of Columbus. March 18. Att. 39.

**Connecticut**

Air Conditioning, by E. D. Milener, Am. Gas Assn., and W. K. Keplinger, Carrier Engg. Corp. March 15. Att. 150.

**Dallas**

Underground Construction and Cable Development, H. K. Doyle, Dallas Pwr. & Lt. Co. March 21. Att. 78.

**Detroit-Ann Arbor**

Vacuum Tubes and Their Application, by E. H. Vedder, Westinghouse Elec. & Mfg. Co. Joint meeting with I.R.E. March 15. Att. 450.

**Denver**

Electric Steel, by J. E. Holtman and J. H. Spillane, Am. Manganese Steel Co. Dinner. March 18. Att. 34.

**Erie**

The X-ray in Industry, by E. W. Page, Genl. Elec. X-ray Corp. March 15. Att. 85.

**Fort Wayne**

The Industrial Applications of Vacuum Tubes, by L. A. Hawkins, Genl. Elec. Co. March 3. Att. 95.

**Houston**

High Pressure Steam System at Deepwater, by H. G. Hiebler, Houston Lighting & Pwr. Co. Inspection of the plant. March 18. Att. 84.

**Iowa**

E. O. Schreve, Genl. Elec. Co., reviewed recent advances made in the development of new products and the improvements in design and manufacture of existing apparatus. Joint meeting with Iowa State Col. Branch. March 1. Att. 58.

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., assist. director of engg., Westinghouse Elec. & Mfg. Co. March 23. Att. 30.

**Kansas City**

The World of Electronics, by L. A. Hawkins, Gen. Elec. Co. Joint meeting with Engg. Societies of Kansas City. Feb. 29. Att. 810.

Surge Proof Transformers, by H. V. Putman, Westinghouse Elec. & Mfg. Co. March 18. Att. 65.

**Los Angeles**

Annual Student meeting under the auspices of the Calif. Inst. of Tech. and the Univ. of Southern Calif. Branches. Some Phases of Institute Work, by A. W. Copley, Westinghouse Elec. & Mfg. Co., vice-pres. A.I.E.E.; Electrical Dehydration, by M. S. Hodge, student, C. I. T.; Study of Pasadena Distribution, by A. Butler, L. J. Wright, E. G. Olinstud, and D. E. Batchelder, students, C. I. T.; Retardation Method of Testing Rotating Machinery, by W. W. Austin, student, U. S. C.; Mathematical Analysis of Retardation Method, by G. R. Little, student, U. S. C. Dinner. March 8. Att. 106.

**Louisville**

The following papers presented by students of the Univ. of Louisville: The Life of Steinmetz, by C. D. Eldridge; The Life of Marconi, by K. A. Dick; The Life of Faraday, by W. G. H. Stafford; Theory of Operation of the Thyratron Tube, by P. Frank; Electrical Eye by Mr. Best. Motion pictures and demonstrations. March 18. Att. 66.

**Lynn**

Miracles in Nature, by A. C. Pillsbury. Demonstrations. March 9. Att. 1200.

The Comparison of Radio Frequencies, by R. S. Davidson; Some Physical Characteristics of Parts Molded From Phenolic and Resinous Compounds, by A. White; Significance of Noise Measurements, by K. H. Pratt; Mechanical Effects of Overcurrent Current Transformers, by A. T. Sinks, all of the Genl. Elec. Co. March 23. Att. 300.

**Madison**

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. March 18. Att. 57.

**Memphis**

Film—"All Steel Electric Welded Houses." March 8. Att. 30.

**Milwaukee**

A Modern Large Electrical Shovel, by P. S. Stevens, Bucyrus-Erie Co. Moving pictures. Feb. 10. Att. 65.

Space Cooling With Ice, by A. J. Authenrieth. Middle West Utilities Corp. Feb. 17. Att. 250.

**Minnesota**

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Dinner. March 21. Att. 75.

**Niagara Frontier**

High Spots in the Design of Steam Electric Power Plants, by I. E. Moultrop, Edison Elec. Ill. Co. of Boston, vice-pres. A.I.E.E. Dinner. March 10. Att. 55.

**Oklahoma City**

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Feb. 29. Att. 115.

**Portland**

The Trend in Power Plant Development, by W. F. Hynes, Genl. Elec. Co. March 15. Att. 76.

**Providence**

Vertical Transportation, by A. S. Noyes, Otis Elev. Co. Dinner. March 8. Att. 40.

**St. Louis**

Surge Proof Transformers, by H. V. Putman, Westinghouse Elec. & Mfg. Co. March 16. Att. 96.

**San Antonio**

Installation and Operation of Electrical Equipment on Battleships, by E. M. See, Genl. Elec. Co. March 28. Att. 18. San Francisco.

**San Francisco**

Principles of Flight and Recent Developments in Aeronautics, by Prof. E. G. Reed, Stanford Univ. March 25. Att. 68.

**Seattle**

Overseas Telephone Service of the Bell System, by W. H. Harrison, Am. Tel. & Tel. Co. Joint meeting with I.R.E. Feb. 19. Att. 250.

Timber Utilization, by C. W. Hogue, West Coast Lumberman's Association; Forestation, by Dean H. Winkenwerder, Univ. of Wash. Joint meeting with A.I.M.E., A.S.C.E., and A.S.M.E. Sections. March 21. Att. 115.

**Sharon**

The Expanding Universe, by F. C. Jordan, director, Allegheny Observatory. March 22. Att. 300.

**Southern Virginia**

Joint meeting with A.S.C.E. and A.S.M.E. Sections, and Engrs.' Club of Hampton Roads. Friday morning, Cecil Gray, chmn., So. Va. Section, A.I.E.E., presiding: History of Sound Pictures, by J. R. McLemroe, Electrical Research Products, Inc. Business meetings. Luncheon, W. P. Tunstall, pres. Engrs.' Club of Hampton Roads, presiding: Welcome address by C. B. Borland, director of Public Safety, City of Norfolk; More Landmarks for the Seafarer, by Lieut. E. B. Roberts, U. S. Coast and Geodetic Survey; News, by W. R. Harris, Norfolk Virginian-Pilot. Friday afternoon, Motor bus trip to Great Bridge, Va. Friday evening, dinner, Prof. A. F. Macconachie, Univ. of Va., presiding: E. M. Hastings, A.S.C.E., toastmaster, Water Purification and Its Relation to the Public Health, by Prof. J. H. Gregory, Johns Hopkins Univ.; Human Engineering, by G. Guy Via, Newport News Shipbuilding and Dry Dock Co. Saturday, Golf and visits to places of interest in the vicinity. March 25–26.

**Spokane**

Some Developments in Talking Pictures, by K. P. Kenworthy, student; The Calibration of a Dynatron Oscillator From Broadcast Harmonics, by M. Herr, student; Power System Frequency Control, by C. Cannon, student. Joint meeting with Univ. of Idaho and Wash. St. Col. branches. March 25. Att. 60.

**Springfield**

Development and Application of Photoelectric Cell, by A. R. Olpin, Bell Telephone Co. Jan. 11. Att. 122.

Television—Its Fundamental, Physical, and Psychological Principles, by J. O. Perrine, Am. Tel. & Tel. Co. Feb. 8. Att. 650.

**Toledo**

Inspection trip through the Rossford plant of the Libbey Owens Ford Glass Co. March 22. Att. 300.

**Toronto**

The Elevator or Vertical Transportation, by E. J. Ellis, Otis Fensome Elev. Co. Illus. March 11. Att. 59.

Electrical Features of New Plants, Mining and Smelting Division, by W. E. Gillespie, Intl. Nickel Co. April 8. Att. 57.

**Vancouver**

Carrier Current Telephony, by H. M. Van Allen, student; The Thyratron Tube, by J. W. McRae, student; Dust Precipitation by Electricity, by J. D. Mitchell, student. Joint meeting with Univ. of British Columbia Branch. March 7. Att. 57.

**Washington**

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Film—"Dynamic America." March 8. Att. 75.

## Past Branch Meetings

**Alabama Polytechnic Institute**

Locating Interference in Radio Receiving Sets, by Prof. J. C. McKinnon; Keeping the Right-of-Way Clear for Power Lines, by R. P. Lapsley, student. March 10. Att. 19.

History and Development of the Clock, by T. Fullau. March 24. Att. 18.

Election of officers: R. W. Wages, chmn.; C. W. Stickler, vice-chmn.; J. W. Solomon, secy.-treas. March 31. Att. 25.

**University of Alabama**

Audible Light, by J. B. Taylor, Genl. Elec. Co. Feb. 20. Att. 1200.

Discussion. March 14. Att. 12.

**University of Arizona**

History, Purposes, and Characteristics of the A.I.E.E., by Prof. J. C. Clark, counselor. Election of officers: P. F. Hawley, chmn.; B. Watkins, vice-chmn.; J. Jones, secy.-treas. Feb. 5. Att. 7.

Steinmetz, by Bruce Watkins, student. Feb. 12. Att. 6.

Faraday, by H. E. Stewart, student. Feb. 19. Att. 7.

Westinghouse, by J. Jones, student. Feb. 26. Att. 6.

Lamme, by R. H. Carson, student. March 4. Att. 9.

Discussion. March 11. Att. 8.

Diesel Engine Generating Plant of the Tucson Gas, Electric Light and Power Co., by Bruce Watkins, student. March 18. Att. 7.

**University of Arkansas**

Outdoor Lighting, by W. C. Warram, student; Amplifiers, by H. D. Albrecht, student. March 7. Att. 24.

Harmonic Analysis, by J. H. Nelson, student; Photoelectric Cells, by L. Williams, student; Commutation, by J. A. Hays, student. March 21. Att. 25.

Radio Beacons, by N. F. Bolling, student; the Permeameter, by G. G. Farris, student; Mercury Arc Lamp, by J. C. Howard; Rural Electrification, by Mr. Robinson, student; Iron Losses, by L. Hildebrand, student. April 4. Att. 24.

**Armour Institute of Technology**

Development of Underground Power Cables and Their Use by the Commonwealth Edison Co., by Herman Halperin, Commonwealth Edison Co. March 4. Att. 40.

Automatic Elevator Control, by L. O. Sinderson, Genl. Elec. Co. Joint meeting with A.S.M.E. Branch. March 18. Att. 33.

Generating Stations of the Edison Company, by E. Peterson, Commonwealth Edison Co. April 1. Att. 40.

**University of British Columbia**

Election of officers: J. W. McRae, chmn.; H. C. Freedman, sec'y. March 23. Att. 19.

**Brooklyn Polytechnic Institute**

Communication With Quasi Optical Waves, by L. DeRosa, student; Electro-Anesthesia, by A. Cross, student; The Barkhausen Effect, by H. Beckman, student; Frequency Control by Use of a Thyratron Tube, by R. Buehl, student. March 16. Att. 43.

Constant Current Transformer, by V. D'Agostino, student; Repairing a Submarine Cable, by H. Hoffman, student; The Life of Steinmetz, by L. Higgins, student. March 23. Att. 49.

**Bucknell University**

J. M. Dobbie elected chairman. March 11. Att. 12.

**University of California**

The Use of Telephone Circuits in the Transmission of Radio Programs, by I. B. Cave, Pac. Tel. & Tel. Co.; Pressure Phenomena in Oil Circuit Breakers, by E. Atkinson, student. March 10. Att. 35.

The Development of the Pit River by the Pacific Gas & Electric Co., by E. A. Crellin, Pac. Gas & Elec. Co. March 24. Att. 28.

**Carnegie Institute of Technology**

The Electrical Engineering Graduate, by A. M. Dudley, Westinghouse Elec. & Mfg. Co. March 9. Att. 17.

**Case School of Applied Science**

Non-destructive Magnetic Testing, by J. Kacmarik, Jr., student; The Practical Significance of Dielectric Power Factor, by R. W. Schindler, student; Ether Drift and Relativity, by Dr. D. C. Miller. Joint meeting with Cleveland Sec. March 24. Att. 180.

**Clarkson College of Technology**

Demonstrations. March 1. Att. 71.
Demonstrations. March 7. Att. 52.

**University of Colorado**

How Radio Has Affected Modern Property Relations, by Dean Stearns, Univ. of Col. Law Sch. March 9. Att. 30.

**Cooper Union**

Inspection tour of the East River Generating Station of the N. Y. Edison Co. February 15. Att. 12.

**University of Denver**

Advantages of the G. E. Test Course for Graduate Engineers, by M. M. Boring, Genl. Elec. Co. March 8. Att. 36.

**University of Detroit**

The Talking Movies, by C. L. Strong, Elec. Research Prod., Inc. Demonstrations. April 6. Att. 55.

**University of Florida**

The Correlation of Solar Disturbances With Radio Transmission, by J. L. Wolcott, student. March 23. Att. 17.

Films—"I See You Calling Me" and "Pictures by Wire." April 4. Att. 38.

**Georgia School of Technology**

Problems Encountered in Network Broadcasting, by J. W. Hutchinson, Am. Tel. & Tel. Co. March 22. Att. 63.

**Harvard University**

Arc Welding, by Prof. C. A. Adams. March 16. Att. 31.

Inspection trip to the L Street plant of the Edison Elec. Ill. Co. of Boston. March 29. Att. 12.

**University of Illinois**

Problems in the Operation of Distribution Systems, by L. Shapiro, Central Ill. Pwr. & Lt. Co. March 9. Att. 40.

**University of Iowa**

Advance in the Art of Steam Generation of Electric Power, by J. M. Drabelle, Iowa Ry. & Lt. Co. March 2. Att. 39.

Photoelectric Cell, by D. E. Duckett, student; Pilot Wire Transmission Regulating Systems, by W. C. Davie, student; Some Experiments Performed on Lightning, by P. A. Colony, student. March 9. Att. 36.

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., and asst. direc. of engg., Westinghouse Elec. & Mfg. Co. March 22. Att. 166.

The Present Practises in the Installation of Power Cables, by W. H. Carl, student; Injuries From Surge Discharges, by J. B. Cutler, student; The Cascade Tunnel, by W. A. Benincosa, student; Telephone Repeater Stations, by A. O. Behnke, student. March 30. Att. 37.

**Kansas State College**

The Recent Supreme Court Decision and the Kansas Public Utility Commission, by Prof. R. G. Kloeffler, counselor; Electric Clocks, by Mr. Elwell, student. March 10. Att. 34. Program repeated same evening. Att. 34.

**University of Kansas**

Automatic Substations, by Prof. R. W. Warner; Crystals and Characteristics of Crystal Control Circuits, by E. Kelley, student. March 17. Att. 39.

**Lafayette College**

Frank H. Welsh elected chairman. March 11. Att. 25.

Short Wave Radio Stations, by C. Markley, student. March 17. Att. 20.

**Lehigh University**

Electrical Aids to Aviation, by L. F. Underwood, student; Engineering Education for Civic Usefulness, by O. W. Eshbach, Am. Tel. & Tel. Co. Illus. March 11. Att. 70.

**Lewis Institute**

A-C. Low Voltage Network Systems, by O. J. DeBever, student. March 3. Att. 30.

Power Development in the Chicago Area, by W. S. Monroe, Sargent & Lundy Co. March 18. Att. 175.

**University of Louisville**

Faraday, by W. H. Stafford, student; Marconi, by Mr. Sutt, student; Steinmetz, by Mr. Eldredge, student. March 14. Att. 21.

**Massachusetts Institute of Technology**

Modern Uses of Electricity in Medicine, by E. W. Schafer, student. March 15. Att. 60.

Inspection trip through the Bowdoin Square exchange of the New England Tel. & Tel. Co. March 23. Att. 25.

Vertical Transportation, by H. S. Duncan, student. Dinner. March 30. Att. 35.

**Michigan College of Mining and Technology**

Electricity in the Army, by C. W. Ball. Prof. G. W. Swenson, counselor, gave a report of the A.I.E.E. winter convention held in New York. March 3. Att. 20.

**University of Michigan**

The Place of Organized Research in Modern Industry, by R. Foulkrod, Michigan Bell Tel. Co. March 3. Att. 60.

Radio Experiences With Garwood, by E. B. Etchells, student. March 24. Att. 10.

Films—"Automatic Arc Welding," "Automatic Substations" and "The Greater Campus." April 5. Att. 40.

**Milwaukee School of Engineering**

Progress Made in Communication to Automobiles by Radio, by H. Wareing, Milwaukee Police Dept. March 9. Att. 94.

**Missouri School of Mines and Metallurgy**

Motion pictures. March 9. Att. 13.

Exhibits. March 18. Att. 150.

Dynamometer, by Joseph Worley, Emerson Elec. Co. April 1. Att. 25.

**Montana State College**

A New Oscillator for Broadcast Frequencies, by Carl Wall; Means of Photographing Oscillograms, by R. Wells; Reducing Transmission Line Radio Interference, by R. Wyman; Transmission and Lighting Studies, by H. Bowman; Electricity From the Sun, by J. Cromer; Two Way Television, by T. Degenhart; all students. Feb. 11. Att. 94.

Electrification of Steam Railroads, by P. Alfers; Safety in the Air, by L. Eisele; Electrified Ice Plant, by C. L. Grebe; Teletypewriter Service, by M. Hilden; Floating Motor Drive Base, by G. Huizings; Achievements in Electrical Engineering in 1931, by J. D. Mathews; A Floating Electric Power Plant, by G. Misevic; Photoelectric Control, by J. Norlin; all students. Feb. 18. Att. 95.

**University of Nebraska**

Airships and the U.S.S. Akron, by V. R. Jacobs, Goodyear Zeppelin Corp. Motion pictures. March 23. Att. 175.

**Newark College of Engineering**

Carrier Currents, by C. H. Stephan, student; Electrically Driven Ships, by W. Arnott, student; Mercury Arc Rectification, by J. Hoerter, student. March 14. Att. 24.

Telemetering, by W. DeRitter, student; Synchronous Reproduction of Sound, by W. H. Gaeckler, student; X-rays, by H. Dorhmann, student. March 28. Att. 16.

**College of the City of New York**

Vacuum Tube Applications, by W. C. White, Genl. Elec. Co. March 10. Att. 150.

Oil-Electric Locomotives, by Mr. Garrison, Ingersoll Rand Co. March 17. Att. 34.

Power House Design, by Mr. Warren, Genl. Elec. Co. Illus. March 24. Att. 27.

**North Carolina State College**

Broadcasting, by H. K. Carpenter, mgr. radio station WPTF. March 1. Att. 30.

**University of North Dakota**

Discussion and motion pictures. March 16. Att. 12.

Electric Arc Welding, by R. D. Florance, student; Remote Wattmeter Reading, by D. F. Field, student. March 30. Att. 16.

**Northeastern University**

Engineering in Japan and Korea, by Prof. A. E. Kennelly, Harvard Univ. Refreshments. March 23. Att. 76.

**Ohio State University**

Election of officers: Len Winkler, chmn.; Charles McCarty, secy.-treas. March 10. Att. 25.

**Oklahoma A. & M. College**

Noise Induction Demonstrations, by C. E. Bathe, Okla. Gas & Elec. Co. and E. B. Jennings, Southwestern Bell Tel. Co. Feb. 1. Att. 14.

Experiences Since Leaving College, by Mr. Bonar, supt. of power plant on college campus. Feb. 29. Att. 20.

Battleships—Their Construction and Special Features, by G. W. Whiteside. March 14. Att. 25.

**Oregon State College**

Safety Education of Engineering Students, by Walter Smith, Mountain States Pwr. Co.; First Aid in Industry, by F. P. White, Mountain States Pwr. Co. Feb. 25. Att. 28.

**Pennsylvania State College**

The Klydonograph and Its Use in Measuring Lighting Surges, by C. E. Laedlin, R. J. Maynard, and J. W. Hostetter, students; Study of Commutator Ripples and Their Effects, by R. Carlson and D. H. Smith, students. March 18. Att. 44.

**University of Pittsburgh**

Recent Developments in Science, by L. Colton, student. March 3. Att. 122.

Economics of Electrification, by Dr. Fitzgerald, Western Maryland R.R. March 10. Att. 116.

Musical program. March 17. Att. 120.

Alternating Current Electrification of Railroads, by H. M. Blackburn, student. March 31. Att. 124.

**Pratt Institute**

Gyro-Stabilizers, by G. H. James, student. March 17. Att. 62.

Employment of Pratt Graduates, by H. P. Miller, instructor. March 31. Att. 75.

**Rensselaer Polytechnic Institute**

Recent Developments in Oscillographs, by A. D. McAffer, Genl. Elec. Co. Demonstrations. Feb. 23. Att. 40.

**Rhode Island State College**

Growth of the Electrical Industry, by Prof. A. E. Watson, Brown Univ. March 3. Att. 21.

Photoelectric Cell, by J. F. Schmidt, student; Experiments Performed on the Banking of Transformers, by G. E. Andrews, Jr. and E. H. Long, students. March 17. Att. 18.

Business meeting. March 31. Att. 9.

Election of officers: L. M. Lang, chmn.; J. P. Costanza, vice-chmn.; W. J. Daly, secy.-treas. April 7. Att. 12.

**Rice Institute**

Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co., outlined the present status of the electrical engineering field. Dinner. Feb. 24. Att. 43.

Problems Encountered in Constructing a Television Transmitter, by F. Kennedy, student. March 9. Att. 22.

**Rutgers University**

Harmonic Analysis Via Fourier Series, by F. P. Fisher, student. March 8. Att. 15.

The Theory of Magnetization and Related Phenomena, by C. I. Bradford, student. March 15. Att. 15.

**University of South Carolina**

The Engineer's Job in Times of Economic Depression, by C. H. Moorefield. Joint meeting with A.S.C.E. Branch. March 17. Att. 101.

Coordination of Light and Music, by W. J. Valentine, student; Is the Steam Train Engine Doomed? by W. G. Shannon, student; Electronic Equipment in Train Control, by A. G. Daniels, student; Life and Works of W. S. Lee, by G. W. Arrants, student. March 23. Att. 31.

Methods of Welding, by J. R. Hopkins, student; Corona Losses, by W. V. Farnum, student; Seeing the World With a Flying Camera, by T. K. Swygert, student; Cable Sheath Corrosion in Underground Conduits, by C. L. Bradley, student. March 30. Att. 36.

Business meeting. April 7. Att. 14.

### South Dakota State School of Mines

H. L. Fry elected chairman. March 23. Att. 32.

Inspection trip through the Homestake mine. March 28–29. Att. 36.

### University of Southern California

Theatrical Illumination, by L. O. Nauman, Otto K. Olsen Elec. Co. Feb. 17. Att. 31.

Thermionic Vacuum Tubes and Their Application to Industry, by W. A. Grimes, Westinghouse Elec. & Mfg. Co. Feb. 24. Att. 25.

Discussion. March 2. Att. 18.

### Stevens Institute of Technology

Modern Developments in Organic Chemistry, by Prof. F. J. Pond. Luncheon. March 15. Att. 38.

### Syracuse University

Protective Relays, by L. M. Kenan, student; Lightning, by F. J. Conklin, student. March 4. Att. 21.

Sound Detection in Water, by H. Francis, student; Demonstration of Television Apparatus, by P. Magee, student; Electrical Power Consumption During Depression, by F. T. Burroughs, student. March 18. Att. 21.

The Jet Rectifier, by A. B. Rowley, student; Demonstration of Ability of Insulation to Withstand High Voltage, by M. E. Hogan, student. March 25. Att. 21.

### University of Tennessee

Pyrometry, by P. M. Bell, student. Jan. 28. Att. 36.

Electric Pye, by C. McCord, student. Feb. 11. Att. 47.

Audible Light, by J. B. Taylor, Genl. Elec. Co. March 11. Att. 410.

### Texas A. & M. College

Power Rates, by J. H. Johnson, student. March 10. Att. 20.

Electrical and Industrial Development of Southwest Texas, by I. Uhr, Genl. Elec. Co. March 24. Att. 85.

### Texas Technological College

Railway Electrification, by T. Haymes, student; Engineering as Related to American Industry, by H. Gray, student; The Life of Michael Faraday, by J. P. Conner, student. March 23. Att. 20.

The Financial Structure of a Utility Company, by H. D. Woods, Texas Utilities Co. April 6. Att. 26.

### University of Utah

Effective Illumination, by L. B. Gawan, Utah Pwr. & Lt. Co., assisted by C. L. Ellerbeck of the same company. March 4. Att. 103.

### University of Vermont

Prof. Buchanan outlined the uses of the oscillograph in detecting disturbances in power systems. March 7. Att. 16.

The Use of the Inverter in Power Transmission, by G. W. Patterson, student. March 21. Att. 16.

### Virginia Military Institute

The Evolution of the Dial Telephone, by T. H. Harrel, student; The Development of the Telephone, by J. S. Lay, student; The Measurement of Frequency, by G. S. Bernard, student; The Development and Use of the Photoelectric Cell, by H. L. Woodson, student. Feb. 27. Att. 72.

### Virginia Polytechnic Institute

Three Power Locomotives, by W. P. Swartz, student; Development of Electrical Power at the Conowingo Power Plant, by R. B. Poque, student; New Telephone Cable, by E. W. Seay, student; Thomas A. Edison As a Man, by N. C. Smoot, student. April 7. Att. 24.

### Washington State College

Dean H. V. Carpenter, vice-pres. A.I.E.E., presented a report of the A.I.E.E. winter convention held in New York. March 11. Att. 17.

Water Power Frequency Control, by C. Cannon, student; Talking Picture Development, by K. P. Kenworthy, student; The Calibrations of the Dynatron Oscillator, by M. Herr, student. Joint meeting with Spokane Sec. and Univ. of Idaho Branch. March 25. Att. 57.

### Washington University

H. Van Bodelschwingh described the educational system used in Germany. Feb. 18. Att. 35.

Discussion. Feb. 26. Att. 70.

### West Virginia University

Westinghouse Electric & Mfg. Co., by E. D. Harris; Colfax Power Plant, by O. B. Spangler; The Mesta Machine Co., by L. Palmer; Carnegie Steel Co., by C. E. Higgins; Development of the Steam Turbine, by F. Q. Brown; Carnegie Steel Co., by G. E. Hervey; Powdered Fuels and Ash Precipitation, by C. B. Withers; all students. April 5. Att. 29.

### University of Wyoming

A Study of Filter and Rectifier Assembly, by F. Wickenkamp, student. March 29. Att. 9.

# Employment Notes

## Of the Engineering Societies Employment Service

## Men Available

### Design and Development

ENGR., 31, 12 yr. Bell System, government plant and field experience on sound picture, radio and telephone (manual, dial, repeater, and carrier current) systems. Design and development of manual and automatic elec. testing equip. Industrail applications of electron tubes. Available immediately. C-9376.

E.E. GRAD., 28, married, desires position in design and development or teaching. One yr. Westinghouse student course; 6 months' Westinghouse design school; 1½ yr. design of industrial motors. Available at once. Location, U.S. C-5051.

ELEC. DESIGNER-ENGR., 27, single, 8 yr. experience in design of complete elec. systems including equip., signals, lighting, elevators, telephone, and miscellaneous secondary systems for New York high office bldg. Writing elec. and elevator specifications. Responsible, capable asst. to engr. Desires position with consulting engr. firm. Available at once. D-586.

E.E., tech. grad., 10 yr. experience d-c. substation design. Thorough knowledge of mercury arc rectifiers and rectifier substations, expert draftsman, knowledge of radio, inventor. Available immediately. East preferred. B-7332.

E.E. GRAD., 37, single, citizen, desires position with engg., mfg., or utility. 6½ yr. in pwr. plant and substation design. 2 yr. elec. furnaces. G.E. engg. courses. Available on short notice. C-2710.

DESIGN ENGR., col. grad., 38, married, citizen; 15 yr. engg. experience including 6 yr. generating plant and substation design, and 3 yr. field experience as tester and supervisor. Desires position with utility, engg., or construction firm. Available immediately. Location, immaterial. D-482.

### Executives

E.E. GRAD., 41, married, E.E., A.M., 12 yr. experience test dept. of large utility. 11 yr. teaching experience in evening engg. schools; 3 yr. design and manufacture of off-peak elec. storage type water heaters; analysis of load curves with a view of improving load factors. Location, immaterial. D-575.

E.E. GRAD., M.I.T., 35, married, 10 yr. experience Gen. Elec. Co. design and development of elec. measuring devices, desires position with holding company, utility or mfg. concern involving exec. and engg. ability. Immediately available. D-607.

E.E. GRAD., married, 36, 12 yr. experience in operation of elec. stations load dispatching and maintenance work. Would like position with utility company on station operating or system operation. D-611.

GRAD. E.E., 50, married, 25 yr. elec. and mech. experience, pwr. plants, concentrating and chemical plants, design and construction on pipe lines, pumps, conveyors, bldg. quarries, elec. mchy. repairing, pwr. plant and hydroelectric and pumping plant design and operation, steel drum mfg. equip., also teaching mech. engg. A-3651.

E.E. GRAD., 31, single, 9 yr. experience with elec. ry. Experience in executive and construction work. Desires connection with future. Available for work anywhere. D-643.

EXEC. ASST., tech. col. grad., 37, 12 yr. diversified experience in all branches of the utility business. Valuation work, rate investigation, cost analysis, statistical and financial research, engg. and sales work. Services offered to a company which can use to advantage a trained utility man. B-9782.

EXEC. ENGR., 41, M.E. and E.E. apprenticeship training. Mgmt. problems, industrial mfg. and utilities. Operation, design, and construction, mchy., pulp and paper, mining and concentration mills, elec., gas, water, and refrigeration system. Industrial engg. and cost accounting, production, waste-incentive system, reorganization work, scheduling, production, budgeting, sales. B-7944.

E.E. GRAD., 37, single, 15 yr. experience, covering pwr. station, substation, telephone equip., and elec. motor design, elec. motor, generator, and transformer test including development, mfg., and service test. 1 yr. postgraduate course on powr. factor, short-circuit, and transmission line calculation. Available now. Location, immaterial. D-637.

GRAD. ELEC.-MECH. ENG., 38, desires connection with utility or industrial firm on pwr. station operation as an engr. or asst. to an exec. 10 yr. experience in pwr. plant test, operation, design, construction, and maintenance. 3 yr. elec. engg. for industrial firms. 2 yr. asst. to pwr. engr. B-8379.

E.E., Univ. of Ill., 17 yr. experience covering design, construction, operation of steam, Diesel and hydro plants and elec. pumping stations. Records show lowered costs and improved service. Good organizer and economical. Fluent Spanish and French. D-660.

E.E. GRAD., 29, married, 7 yr. broad experience, pwr. house, substation, and transmission line design; major apparatus application, cost estimate, and equip. specifications. Excellent references. Desires connection with holding company, utility, or mfr. Location, South or East preferred. D-678.

E.E. GRAD., 1924, Univ. of Md., married, 8 yr. gen. experience in construction, design, and layout of substations for a large utility. Special experience in relay protection. Available in 6 wk. D-701.

E.E., 38, married, with 13 yr. experience signal and communication systems. Experienced inspection supervisor, methods engr., estimator, development and equip. engr.; 6 yr. experience as supervisor. 5 yr. tech. col. Available at once. C-2982.

E.E., 35, married, 3 yr. central station engg. proposals, sales construction. 7 yr. pwr. and industrial station wiring diagrams, conduit layouts, substation design, automatic, and supervisory equipments, rr. electrifications. Foreign languages. Available on short notice. Location, immaterial. D-710.

E.E. AND M.E. GRAD., married, 22 yr. experience, designing, construction pwr. plants, substations, transmission, distribution system, industrial plants. 3 yr. charge purchasing engg. equip., foreign interests. 3 yr. exec. experience charge engg. dept. large utility syndicate. Languages, English, German, Russian, Armenian, and Turkish. Available immediately. D-84.

GRAD. ENGR., 30, married, 2 yr. telephone switchboard testing, 1 yr. shop mech., 1 yr. municipal engg., 2 yr. designing and drafting for large copper smelter, last 3 yr. designing and drafting for large oil refinery. Desires position as asst.

to dept. head. Go anywhere. Pacific Coast preferred. C-4015.

E.E. GRAD., married, 37, wide experience in industrial plant elec. construction and maintenance; desires position in plant engg. with future. D-734.

TELEPHONE ENGR., 30, univ. grad., 10 yr. experience in design of outside plant, maintenance and specifications. Bell and independent experience. Successful in handling men. Desires opportunity with operating or holding company. D-736.

GRAD. E.E., 34, married, 10 yr. practical automotive maintenance. G.E. Test. 3 yr. designing industrial motors, d-c. arc welding equip. 3 yr. developing, designing transportation motors, control. 3 yr. automotive maintenance engg. with large bus, cab company. Interested in elec. automotive engg. D-95.

E.E., 33, married, desires position, mfr. of radio or public address systems, broadcasting station, or carrier dept. of elec. pwr. company. 4 yr. design, construction, operation, testing of equip. for elec. pwr. stations. 6 yr. installation, wiring, testing radio broadcast, tel. and tel. repeaters and carrier equip. Excellent references. D-733.

E.E. GRAD., 1924 M.I.T. cooperative, 30, married. G.E. Test; 5 yr. designing and application engr., ry. motors and equip., 2 yr. asst. to work-production mgr., in charge of all large apparatus contracts. Desire engg. or administrative position with mfr., utility or engg. firm, or teaching. Available immediately. D-760.

### Foreman

FOREMAN OR CHIEF ELECTRICIAN, expert, armature winding, motor repairs, and trouble. Install wiring systems for light and pwr. Extensive practical experience. D-657.

### Instruction

E.E. PROF., B.S. and E.E., 33, married, 2½ yr. G.E. Co., 5 yr. with utility, 4 yr. teaching, 1 yr. as acting head of dept. Desires change. Location, South or Middle West preferred. C-7152.

DIRECTOR OF EDUCATION AND TRAINING with natl. tech. corp., formerly asst. prof. of E.E., B.S. and M.S. in E.E. Experienced in exec. and administration phases of educational work. Desires position as prof. or assoc. prof. of E.E. Location, immaterial. C-8967.

GRAD., E.E. 36, 8 yr. construction, maintenance large and small pwr. plants in this country and abroad. 4 yr. mech. production design including gas engines. At present doing grad. work Univ. of Calif. Desires instructorship, elec. mech. engg. with opportunity for research. Pacific Coast, South preferred. Available June. D-639.

E.E. GRAD., 28, married. B.S. Wash. Univ., desires position teaching mathematics, E.E. subjects or lab. work. 3 yr. design street lighting, 3 yr. selling elec. instruments and substation equip. Location, immaterial. D-688.

E.E. GRAD., 1929, single, 26, now attending leading eastern univ. working for M.S. in E.E. 15 months G.E. Test course including rectifiers, industrial control, research, ry. equip., motors, shop and elec. construction experience before graduation. Desires position, utility, mfg. or teaching. Available June. Will go anywhere in the U.S. C-9003.

GRAD. E.E., M.I.T. 1920, 35, married. Entire experience since then in E.E. teaching and industrial work. Good ability and personality. Desires work in E.E. teaching. Salary open. C-2826.

CORNELL GRAD., E.E. in 1929. Has had 2½ yr. experience in design and manufacture of automatic temperature control equip. for oil refineries and regenerative furnaces. Some experience in tutoring and teaching. Desires position with mfr. of automatic control equip. or as an instructor in college. D-690.

PROF., ASSOC. PROF. E.E., 39, B.S. and E.E., Univ. of Colo. Practical experience with pwr., telephone, mining, and elec. mfg. concerns. 6 yr. on the E.E. faculty of state school. Now employed but available for school year. C-5021.

INSTRUCTOR OR ASST. PROF., 38, 8 yr. instructor in E.E., radio, physics in univ.; 5 yr. commercial experience, lighting, pwr., and radio installations, research, and design. At present research assoc. in physics in post grad. school of well known univ. Available for next September. C-6302.

DEAN OF ENGG. Mature engr.-teacher, 10 yr. experience, engg. faculties, followed by 15 yr. extensive experience engg. practise. Would consider position as dean of engg. in institution where recognition of present day needs, and ability to meet these needs is desired. Full details supplied, or personal interview arranged upon request. C-6733.

FORMER CORNELL INSTRUCTOR IN MACHINE DESIGN for 4 yr. M.E. and E.E. grad. Allis-Chalmers designer and checker 5 yr., shop apprenticeship and miscellaneous experience. 32, single. Desires teaching or engg. opportunity. Salary open. D-122.

PROF., E.E., Ph.D., 44, 8 yr. excellent teaching experience as well as practical engg. experience. B-660.

GRAD., with Master's deg, 29, married, now substation design engr. for southwestern pwr. company. 5 yr. tech. experience, 7 yr. teaching experience in college physics and mathematics, desires teaching or research position. Best of references. Preferred location, Pac. coast, but any considered. Available on short notice. D-746.

E.E. GRAD., Midwestern col., 1931, single, 24, American. Excellent scholastic record. Desires teaching opportunity. Will teach E.E., mathematics, or mechanics. Location, immaterial. D-570.

INSTRUCTOR, now teaching engg. physics, wishes to locate with school or as private tutor for the summer. Permanent position would also be considered. Well versed in the practical side of engg., and in such extra-curricular subjects as photography, dramatics, and nature study. C-9916.

E.E. GRAD., 1929, G.E. Test experience including work in radio and vacuum tube engg. dept., and with all types of elec. mchy. Will receive M.S. this June. Desires a teaching or engg. opportunity. C-1879.

MECH.-ELEC. ENG. grad., 37, married, 10 yr. experience, design and maintenance of telephone and pwr. circuits with Western Elec. and operating companies. 4 yr. experience, teaching and research work in elec. engg. 2 yr. experience, sale of Diesel and Diesel elec. pwr. Location preferred, eastern. Salary open. Available immediately. C-6340.

### Junior Engineers

1932 GRAD., 24, married. Wants a job now. Far West only. D-612.

E.E. GRAD., 1930, single, 24, 18 months G.E. Test and service shop experience. Some calculating and drafting. Good student record, ambitious, reliable. Desires position with utility or industrial concern. Prefer South West or Far West. Available immediately. D-628.

1931 E.E. GRAD., Clemson Agri. Col., 25, single, Desires work with utility, mfg. concern or construction corp. Available immediately. Location, immaterial. D-400.

E.E. GRAD., 1929, 25, single, 2½ yr. experience in design and engg. of high tension outdoor and indoor substations. Desires position connected with hydroelectric development. Location desired, South. C-5967.

E.E. GRAD., 1931, Univ. of Wis., 26, single, 10 months' experience in utility construction; 2 yr. machine shop and garage. Interested in television. Location and salary immaterial. Available at once. D-640.

GRAD. E.E., 26, married, B.S. with honors 1930. 1 yr. experience with utility as a student cadet; 6 months' experience testing and treating boiler feedwater. Desires position with utility, operation or construction or with a radio mfg. company. D-673.

GRAD. E.E., Columbia Univ., 1932; single, 23, 4 yr. with research dept. of Bell Tel. Lab.; wishes to teach E.E. subjects, either full time, or part time, research or study, to obtain Master's deg. Location and salary immaterial. Available June. D-652.

GRAD. E.E., 1929, 8 months' G.E. Test, motors, generators, industrial control, vacuum tubes; 1 yr. inspection of engravings and electrotypes in pre-make-ready dept. of progressive publishing company, partly analysis. Vacation experience surveying transmission line and sewer construction. Desires work under engr. C-7975.

E.E. GRAD., June 1932, Georgia Tech, 24, single, experience in amateur radio, radio sales, and service, bookkeeping. Desires position in any E.E. field. Location, immaterial. Available after June 6, 1932. D-683.

E.E., grad. 1928, married, 3½ yr. industrial testing experience, particularly in motor and control; also civil engg. and supervisory experience. Not afraid of responsibility. Desires a position with future. Location, immaterial. C-9568.

E.E. GRAD., 27, married. Design of pwr. plant, substation, and pwr. transmission lines. Industrial remote control. Also broad experience on appraisals of utilities. Available immediately. Location, immaterial. D-679.

E.E. GRAD., 1929, single, 23, 15 months student engr. on G.E. Test. Some test, drafting, and switchboard construction experience before graduation. Interested in position with a firm doing consulting or construction work or with utility or mfr. Available at once. Location, anywhere in U.S., New England preferred. C-8028.

GRAD. E.E., 22, single, Univ. of North Carolina, 1931. Extra study liberal arts and commerce schools. Desires position any engg. field, preferably telephone work. Four summers experience Ill. Bell Tel. Co., installation and maintenance. Salary immaterial at start. Any location either foreign or U.S. acceptable. Available immediately. D-527.

1931 GRAD. E.E., M.S. of large cooperative school, 24, single with dependents. Experience includes machine shop, drafting, clerking, armature winding, research assisting, and general maintenance and test experience with pwr. co. Desires position teaching elec. subjects, mathematics, mechanics, drawing or physics anywhere in U.S.A. Also interested in research. D-72[illegible].

GRAD. E.E., 1931, U. of M., single, 22, 7 months' student sales engr. Wagner E. Test; 9 months' experience elec., maintenance and construction of industrial equip., Ford Motor Co., 6 months' salesman. Desires position, elec. motor industry, or utility with opportunity for advancement. Location, Mich., and adjacent states preferred. Available immediately. D-719.

JR. ENGR., E.E. GRAD., V.P.I. 1930, 24, 1½ yr. experience as utility engr. with large engg. corp. References. Desires connection with large mfg. plant, electrochemical corp. or utility corp. Anything considered. Available immediately, Location, immaterial. D-735.

1931 GRAD. E.E. from leading college in N. Y. State, 25, desires position in the elec. industry. Experience main motive. Several languages. Location U.S.A., foreign. Available immediately. D-164.

1931 E.E. GRAD. Mid-West univ., 23, single, 3 months' experience with large utility. Desires position with any mfg. firm or utility. Best of references. Location, immaterial. C-9984.

E.E. GRAD., 1931, cooperative, single, 25, American citizen. Tech. high school education in France. Fluent French; some German and Spanish. Experienced in radio and sound research. Training in pwr. and commercial engr. Available at once. Location, immaterial. D-743.

## ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
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205 West Wacker Drive
Chicago

31 West 39th St.
New York

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

**Men Available.**—Brief announcements will be published without charge repeated only upon specific request and after one month's interval. Names and records remain on file for three months, renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

**Opportunities.**—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

**Voluntary Contributions.**—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

**Answers to Announcements.**—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

E.E. GRAD., Feb. 1932, Univ. of Mich., single, 24. Special training in illuminating engg., experience as electrician and contractor. Perfect knowledge of Russian and advanced German. Citizen of U.S. Salary and location immaterial. Available immediately. Recommendations. D-744.

E.E. GRAD., 23, Sc.M. M.I.T., Harvard 28; will receive Sc.D. M.I.T. June '32; single, 38; 8 yr. practical experience pwr.-business and communication engg.; 2 yr. testing course. Recently made valuable contribution to knowledge network synthesis.—Speaks Swedish, English, German. Reading knowledge French. Desires position, well-known organization preferably communication engg. Available. D-747.

GRAD. E.E., 24, single. Wants any position in a utility, with opportunity to prepare for advancement second in consideration to salary. Location, immaterial. Available immediately. Experience as meter tester, lineman, appliance sales and service man, draftsman, and asst. to dist. engr. C-9957.

E.E. GRAD., 1930 Columbia 6 yr. course, 25, single, $1\frac{1}{2}$ yr. with Paramount Publix Theatre Construction. Knowledge sound and projection equipment, drafting, supervision of construction and layout; instruments, foundry and pattern shop methods. Desires connection, any engg. capacity. Available immediately. Present location New York, but willing to go anywhere. C-7239.

GRAD., Mechanics Inst. 1926, 25, single. Experience. 1 yr. designing pwr. and substations; 3 yr. operation and control engr. utility; 2 yr. switchboard engr.; temporary position 5 months, elec. instructor, techn. school. Engg. or teaching position desired. Location, U.S.A. or Canada. D-741.

1931 GRAD., Brown Univ., experience in publication work, editorial and advertising. Good mgr. Stresses personal side of engg. Specialized knowledge of d-c. and a-c. mchy., transmission lines, auxiliary apparatus, testing, and application. General knowledge of drafting, hydraulics, mechanics, thermodynamics, and structures. Clever, industrious, and dependable. D-742.

E.E. GRAD., Univ. of Mich. 1930, 27, single, 2 yr. experience utility distribution engg., desires position in utility or engg. company. Available on short notice. Location, immaterial, domestic or foreign. D-740.

E.E. GRAD., 1930, 23, single, 15 months on G.E. Test, on ry. equip., rectifiers, industrial apparatus, industrial control, and refrigeration development. Desires position with utility or mfg. concern. Available at once. D-409.

E.E. GRAD., 1928, married, 29. Desires work on radio or photophone equip. Experience; 2 yr. installing and servicing X-ray and physical therapy equip.; 1 yr. research and development on speakers, auditorium, and photophone equip. with R.C.A. Victor Co. Prefer eastern or southern U.S. C-4220.

E.E., 27, 1 yr. practical experience, Westinghouse Co., testing motors, generators, transformers, steam turbines, relays, and control equipment; 3 yr. with a pwr. company, substation layouts, cost analysis, estimating, drafting, and development work. D-748.

E.E. GRAD., Univ. of Ill., single, 22. Excellent scholastic record. Experience in utility engg. and in control research and design. Good references. Available immediately. Any location. D-759.

M.E. GRAD., Stevens Inst. of Tech., 24, single, 8 yr. in elec. work for light and pwr. of all descriptions. Also communication knowledge with experience. Location, immaterial. C-9976.

**Maintenance and Operation**

E.E. GRAD., married, 28, with wide experience in industrial plant elec. construction and maintenance; ry. electrification; pwr. plant design, estimating, and supervisory construction experience with elec. contractor; cost analysis. Desires position with future. C-4428.

GRAD. ENGR., 32, married, 1 yr. telephone engg.; 5 yr. construction, operation, test and maintenance of underground transmission, and distribution cable and equip.; 3 yr. transmission and distribution engg. D-623.

COMMUNICATION ENGR. Broad theoretical experience telegraph, telephone, radio, etc., design, installation and maintenance. Many years foreign service. Available U.S. or abroad on short notice. C-8805.

E.E. GRAD., 1928, 6 yr. hydro and steam plant elec. operation and maintenance; 5 yr. office and cost accounting, expert stenographer and bookkeeping. Desires position with utility or mfg. concern in any part of U.S. or foreign. C-7796.

**Production**

INDUSTRIAL ENGR., E.E. grad., 28, married. Now employed by large mfr. of elec. equip.; 2 yr. experience test engr.; 4 yr. wage incentive installation, including job analysis, methods engg., time study, cost control, and supervising wage system operation. Excellent references. D-737.

**Research**

E.E., B.S., E.E., 28, single. Experience: Testing a-c. and d-c. machines in process of construction. G.E. Test course. Drafting, designing of elec. testing equip. Developmental work on instruments and instrument transformers. Work preferred: Development, layout, installation, maintenance of plant equip. in industrial pwr. company. Location preferred: East, Middle West. D-726.

JR. ENGR.-STATISTICIAN: B.S. in E.E. 1930, 25, single, $1\frac{1}{2}$ yr. statistical and economic research experience. Thorough tech. and business training. Speaks Spanish fluently. C-7551.

**Sales**

E.E. GRAD., 1929, 27, single, 2 yr. exceptional experience as jr. engr. with pwr. co. including commercial, engg., construction, and pwr. plant, 1 yr. experience pwr. sales and industrial engg., Desires position preferably in pwr. sales or industrial engg. Excellent references. Location, South preferred. Available at once. D-605.

SALES MGR., ENGR., 35, experienced capable sales contact man, desires connection as representative or mfr. agt. with high grade company mfg. line of high or low voltage equip. for utilities or industrial plants. B-4067.

SALES ENGR., grad. E.E., 33, married. Excellent background of sales and adv., desires connection with mfr. Location preferred, Middle West. Experience in industrial adv. in addition to engg. and selling of elec. equip. Excellent references. B-8614.

SALES ENGR., single, grad. Kansas Univ. '29. G.E. Test course including photophone, radio, industrial control, motors, transformers, and quotation work; 8 months engg. street ry.; 5 months sales engg. with large dealer in new and rebuilt elec. mchy. Now employed. D-674.

ENGR. (British), now engaged, desires correspondence with mfr. in U.S. desirous of establishing branch industries on other side. Also familiar with Canadian, Indian, and African conditions. D-699.

SALES ENGR., E.E. grad., 30, married, 1 yr. testing and engg. western utility; 2 yr. testing; $4\frac{1}{2}$ yr. design, application, and sales engg. with G.E. Desires permanent connection engg. or sales dept. with utility or mfr. Available at once. New York State or East preferred. D-696.

SALES ENGR., col. grad., 36; G.E. Test (steam and elec.) also factory and district office sales experience. For last few years employed as senior industrial engg. representative (elec.) with outstanding central station company. Would like new affiliation preferably in the East. C-5618.

SALES ENGR. OR MFRS. AGT., grad. E.E., 32, over 5 yr. utility in construction, maintenance, and design, over 3 yr. as sales engr. for elec. mfr., including about 3 yr. as jr. exec. Location, immaterial for salary position. Pittsburgh headquarters as mfrs. agt. D-745.

# Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Berry, Wayne J., c/o Genl. Elec. Co., Schenectady, N. Y.
Bugg, Vernon, 736 Transportation Bldg., Washington, D. C.
Du Rieu, E. F., c/o Tate & Hays, 341 Madison Ave., N. Y. City.
Iwe, Halfdan G., 229 Ovington Ave., Bklyn., N. Y.
Miyamoto, Tatsuo C., 1330–4th St., Sacramento, Calif.
Palit, Hari-Charan, 151 Ganesh Mohal, Benares City, India.
Rogge, C. A., Consumers Pwr. Bldg., Jackson, Mich.
Scanlon, D. L., KFPW, Ft. Smith, Ark.
Schwartz, Carl, 410 Cathedral Pkwy., N. Y. City.
Thomas, Earl Mead, Intl. Genl. Elec. Co., Schenectady, N. Y.
Titland, Trygve T., 1019 Stanton Ave., Elizabeth, N. J.
Van Ness, L. G., 2105–6 Sterick Bldg., Memphis, Tenn.

# Membership

## Applications for Election

Applications have been received by the secreatry from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the assistant national secretary before May 31, 1932.

Anderson, C. J., Barber-Colman Co., Rockford, Ill.
Bailey, R. S., Kansas Gas & Elec. Co., Wichita (Applicant for reelection)
Caldwell, C. W., Univ. of South Dakota, Vermillion
Colclough, O. T., Consumers Pwr. Co., Muskegon Heights, Mich.
Cordray, R. E., Genl. Elec. Co., Phila., Pa.
Cotter, M. T., 1001 W. Clay St., Ukiah, Calif.
Dilley, M. M., Automatic Safety Signal Gate Co., Louisville, Ky.
Dumelow, L. S., 34 Church St., Alton, R. I.
Elley, A. C., Yates-American Machine Co., Beloit, Wis.
Fields, C. W., Jr., New York & Queens Elec. Lt. & Pwr. Co., Flushing, N. Y.
Gibson, N. R. (Member) Buffalo, Niagara & Eastern Pwr. Corp., Buffalo, N. Y.
Gray, T. J. (Member), Pub. Serv. Co. of Colo., Fort Collins
Guptill, C. F., United Electric Lt. & Pwr. Co., N. Y. City
Harvey, J. H. (Member), Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Hildebrand, A. M., Lake Erie Pwr. & Lt. Co.; Lake Shore Elec. Ry. Co., Sandusky, Ohio
Horton, H. M., Okla. Gas & Elec. Co., Okla. City
Jelinek, U., 132 Smith St., Elizabeth, N. J.
Kersten, A. W., Wisconsin Tel. Co., Milwaukee
Klaus, C. E., Westinghouse Elec. & Mfg. Co., Portland, Ore.
Kolks, R. H., Union Gas & Elec. Co., Cincinnati Ohio
Leha, H., 1369 Freemont Place, Elizabeth, N. J.
Litchfield, W. L., 28 Spring St., Danbury, Conn.
Mansfield, W. A. Conduits Co., Ltd., Toronto, Ont., Can.
May, R. W., Dept. of Public Works, N. Y. City
McTwiggan, T. L., 130 Rich Ave., Mt. Vernon, N. Y.
Michel, C. B., Bell Tel. Co. of Pa., Philadelphia
Milligan, J. W. (Member), Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Niemann, W. H., Intl. Time Recording Co., San Antonio, Tex.
Rosecky, J. J., Univ. of Wisconsin, Madison
Rote, F. J., Brooklyn (B. Y.) Edison Co., Inc.
Rowe, W. H., Genl. Elec. Co., Lynn, Mass.
Sykes, W. E., Bell Tel. Co., Toronto, Ont., Can.
Tweedle, C. E., L. S. Vallely & Co., Houston, Tex.
Webb, R. B., Southwestern Bell Tel. Co., Dallas, Tex.
Weil, C. R., Gould Storage Battery Corp., Depew, N. Y.
35 Domestic

### Foreign

Ali, S. N., H. H. Government, Patiala State, Punjab, India
Crisp, H. K., Municipalities of Bowral and Mittagong and Shire of Nattai Bowral, N. S. W., Australia
Gokli, K. N., R. Gokli & Co., Matunga, Bombay, India
Gomez, A., Chilean State Rys., Valparaiso, Chile, So. Am.
Perry, A. M., Hachbridge Elec. Construction Co., Surrey, England
5 Foreign

# Engineering Literature

## New Books
### in the Societies Library

Among the new books received at the Engineering Societies Library, New York, during March are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no reponsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

TABLES ANNUELLES DE CONSTANTES ET DONNÉES NUMÉRIQUES de Chimie, de Physique, de Biologie et de Technologie, v. 8, 1927–8, Pt. 1. Paris, Gauthier-Villars et Cie; N. Y., McGraw-Hill Book Co., 1931. 1101 p., 11x9 in., cloth, $10, Pt. 1.—Presenting a year by year compilation of the numerical constants and data that have appeared in the important scientific periodicals. The present part covers mechanics, heat, light, electricity, and magnetism. Titles and explanatory matter are given in English as well as in French.

ADVANCED ELECTRICAL MEASUREMENTS. By W. R. Smythe and W. C. Michels. N. Y., D. Van Nostrand Co., 1932. 240 p., illus., 9x6 in., cloth, $3.00.—Intended for training in the use of research methods and instruments and testing, and development work; a course given to senior students at the California Institute of Technology. Standard electrical measurements are included; also methods for measuring temperature, radiation, and other quantities not primarily electrical. The theory of each method is discussed, and references for further reading provided.

APPLICATIONS OF REFRIGERATION. Book J. By C. T. Baker and I.C.S. Staff. Scranton, Pa., Intl. Textbook Co., 1929. 44 p., illus., 8x5 in., cloth, $1.25.—A description of the principles and construction of the most popular types of refrigerating machines. Automatic for commercial and domestic use.

ARTIFICIAL LIGHT AND ITS APPLICATION IN THE HOME. By the com. on res. ltg. of the Illum. Engg. Soc., Mariquita Dygert, Chmn. N. Y. & Lond., McGraw-Hill Book Co., 1932. 145 p., illus., 9x6 in., cloth, $1.50.—A concise, practical book on the lighting of residences, prepared by a group of authorities and endorsed by the Illum. Engg. Soc. Primarily a text for students of home economics, but also of use to housewives in search of simple, reliable information on artificial lighting.

BOOK OF METALS. By D. Wilhelm. N. Y. & Lond., Harper & Bros., 1932. 341 p., illus., 10x7 in., cloth, $4.00.—A story of industrial metals, their history, mining, refining, alloying characteristics, and uses. Breezy and popular, but read and accuracy approved by acknowledged authorities. For needs of general information on the metals.

DIE ELEKTRISCHE FERNÜBERWACHUNG UND FERNBEDIENUNG FÜR STARKSTROMANLAGEN UND KRAFTBETRIEBE. By M. Schleicher. Berlin, J. Springer, 1932. 238 p., illus., 9x6 in., 21 rm.—Remote control and supervision of machinery and power methods are presented systematically. Calling attention to underlying principles and fields of usefulness rather than to details of instruments. Remote metering, signaling, and control are considered. Bibliography.

DYNAMICS OF ENGINE AND SHAFT. By R. E. Root. N. Y., John Wiley & Sons, 1932. 184 p., illus., 9x6 in., cloth, $3.00.—For 12 years Prof. Root has given a course at the postgraduate school, Naval Academy upon this subject, and the results of his experience appear in this brief textbook. It aims to present methods for evaluating the forces that operate in a reciprocating engine, to trace their effects in turning moment on the shaft and in bearing pressures, and to reveal their significance in relation to vibrations. The book also treats of torsional and transverse vibrations of elastic systems and discusses critical speeds.

FREILEITUNGSBAU MIT SCHLEUDERBETONMASTEN. By L. Heuser and R. Burget. München & Berlin, R. Oldenbourg, 1932. 176 p., illus., 10x7 in., paper, 10 rm.—A comprehensive account of the history and construction of the hollow concrete pole and its use for overhead electric lines. Discusses design and testing of poles, transport and erection, costs, and applications to power, telephone, and telegraph networks. Includes table of all the European lines on concrete poles.

GENL. ENGG. HANDBOOK. Edited by C. E. O'Reurke and others. N. Y., McGraw-Hill Book Co., 1932. 921 p., illus., 8x5 in., leath., $4.00.—In preparing this compendium of engineering data, attempt has been made to compress the important fundamentals of engineering into a single small volume which will supplement detailed handbooks devoted to one field. Divided into 31 sections, six devoted to subjects of interest to all engineers. The remainder treat the major branches of civil, mechanical, and electrical engineering. Each section by an expert in its field.

HANDBOOK OF BUSINESS ADMINISTRATION. W. J. Donald, ed. N. Y. & Lond., McGraw-Hill Book Co., 1931. 1753 p., illus., 7x5 in., leath., $7.00.—An encyclopediac presentation of current practise in all departments of business, prepared specialists and sponsored by the Am. Mgmt. Assn. Marketing, financial production, and office management; personnel and gen. mgmt. are discussed in all ramifications. A concise, handy summary of the policies of many business leaders.

JOBS, MACHINES, AND CAPITALISM. By A. Dahlberg. N. Y., Macmillan Co., 1932. 252 p., illus., 8x6 in., cloth, $3.00.—The author believes that capitalism as a system of economy has not had a fair trial and that under certain conditions it can secure all and more than communism, while avoiding the major difficulties and evils of the latter system. The evils of capitalism would disappear, he believes, were it forced to work under a chronic scarcity of labor rather than a chronic scarcity of job and business opportunity. A method for accomplishing it is suggested.

LEHRBUCH DER RADIOAKTIVITÄT. By G. v. Hevesy and F. Paneth. 2. Auflage. Leipzig, J. A. Barth, 1931. 287 p., illus., 9x6 in., paper, 22 rm; bound, 24 rm.—The aim of the authors of this work has been to supply a text-book concisely covering the whole field of radio-activity, in which due attention is paid both to its physical and chemical aspects; its relations to other branches of science are indicated. Revised and partly rewritten.

LUFTBEHANDLUNG IN INDUSTRIE— UND GEWERBEBETRIEBEN. By L. Silberberg. Berlin, J. Springer, 1932. 174 p., illus., 10x6 in., cloth, 18 rm.—On air conditioning; intended to provide an account of current practise for engineers and factory owners. An introduction devoted to scientific principles, the technique of air conditioning is discussed at some length. The solution of problems involved, and the apparatus used are considered, with advice on systems and operating costs.

MANUAL OF ELECTRIC ARC WELDING. By E. H. Hubert, ed. N. Y. & Lond., McGraw-Hill Book Co., 1932. 163 p., illus., 9x6 in., cloth, $2.00.—Explains the fundamentals of arc-welding processes, with practical suggestions for performing various welding operations and many uses of arc welding. Clear and full, presenting main facts. Sponsored by the welding section of the Natl. Elec. Mfrs. Assn.

MATHEMATICAL TABLES, v. 1. Circular and hyperbolic functions, exponential sine and cosine integrals, factorial (Gamma) and derived functions, integrals of probability integral. Lond., British Assn. for the Advancement of Science, 1931. 35 p. text + 72 p. tables, 11x9 in., cloth, 10s.—For over fifty years the British Assn. for the Advancement of Science has published from time to time mathematical tables in its reports. A selection of these now appears in revised and extended form in this volume. The tables are indicated by titles, most of them extend to twelve or fifteen decimals and include facilities for interpolation. Construction explained in the introduction. The page is large and open and the type clear.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN GHH-KONZERN, Bd. 1, Heft 9, p. 201–24, Jan. 1932. Berlin, VDI-Verlag, illus., 12x9 in., paper, 2.70 rm.—The subjects discussed are: the considerations governing the choice between private and public electric plants, the economical use of rotary well drilling plants, the sustained tractive power of Diesel automobile engines, and the determination of the speed and acceleration of valves of high-speed internal-combustion engines.

MOTORBUS TRANSPORTATION. 4 v. By I.C.S. Staff. Scranton, Pa., Intl. Textbook Co., 1931. illus., 8x5 in., cloth, Book 1, $1.75; Book 2, $1.25; Books 3 & 4, $1.00 each.—Volumes cover the subject concisely yet comprehensively. The organization of bus companies, laws relating to them, operators, financial problems, equipment, maintenance, management, and other important topics are considered, and current practise in these matters is indicated.

NATL. ELEC. CODE HANDBOOK. By A. L. Abbott. N. Y., McGraw-Hill Book Co., 1932. 473 p., illus., 8x5 in., leath., $3.00.—This book is intended as a reference book for users of the Code and a text-book for a systematic study of it. Rules are grouped in a way to enable all applying to a given device or method to be found at once, their meaning clarified by comments, explanations, and diagrams.

PATHWAYS BACK TO PROSPERITY. By C. W. Baker. N. Y. & Lond., Funk & Wagnalls Co., 1932. 351 p., 8x6 in., cloth, $2.50.—A well-known engineer and economist analyzes the underlying causes of the economic and social difficulties of today and points out the paths to renewed prosperity. He finds chief requirement a more general distribution of wealth.

PHOTOELECTRIC PHENOMENA. By A. L. Hughes and L. A. Du Bridge. N. Y. and Lond., McGraw-Hill Co., 1932. 531 p., 9x6 in., cloth, $5.00.—This work aims to provide a concise, yet comprehensive critical survey of the whole field of photoelectric phenomena. The present status of the three major branches of photoelectricity, surface, volume, and photovoltaic effects is summarized; fundamental laws, their experimental bases, and theoretical significance are discussed, and their practical applications briefly reviewed. No formal bibliography, but ample bibliographic footnotes.

PROFITABLE PRACTISE IN INDUSTRIAL RESEARCH. Edited by M. Ross, M. Holland and W. Spraragen, prepared under the auspices of the Natl. Research Council. N. Y. & Lond., Harper & Bros., 1932, 269 p., 9x6 in., cloth, $4.00.—A symposium by the directors of some of the greatest industrial research laboratories of the country. The philosophy and practical application of industrial research, the organization of research departments, the selection of research workers, research work in foreign countries, the part played by trade associations, the government and universities, and the transference of the results of research to the factory all are discussed.

REWINDING DATA FOR D-C. ARMATURES. By G. A. Van Brunt and A. C. Roe. N. Y., McGraw-Hill Book Co., 1932. 212 p., illus., 9x6 in., cloth, $2.50.—Gives practical directions for taking and recording, in a uniform, systematic manner, the information for repairing these armatures. Also the rules governing the various types and windings, and chapters devoted to materials, insulation, banding, dipping and baking. Several chapters on "frog-leg" windings. Expanded from articles that appeared in "Maintenance Engineering."

STANDARD WIRING FOR ELEC. LT. AND PR. By H. C. Cushing, Jr., 38 ed. N. Y., H. C. Wushing, Jr., 1932. 488 p., illus., 7x4 in., leather, $3.00.—A new edition of a well-known guide like its predecessors sets forth clearly and fully the essential requirements for safe and efficient wiring and construction and the latest engineering practise. Complies with Natl. Electric Code.

COLOUR SCIENCE, Part 1. By W. Ostwald. Authorized translation with introduction and notes by J. S. Taylor. The April issue of ELECTRICAL ENGINEERING gave the address of the publishers, Winsor & Newton, Ltd., as London. They are of London and New York.

**Engineering Societies Library**

29 West 39th Street, New York, N. Y.

MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

# Industrial Notes

**Multiple "V" Belt Patent Suit Settled.**—The Allis-Chalmers Manufacturing Company announces that the suit between it and the Dayton Rubber Manufacturing Company, of Dayton, Ohio, in the United States District Court at Cincinnati, involving patent infringement of Allis-Chalmers Geist patent No. 1,662,511 pertaining to multiple "V" belt drives has been settled out of court. The Dayton Rubber Manufacturing Company takes a license under the Geist patent and the Allis-Chalmers Manufacturing Company has the right to operate under Short patent No. 1,538,303, if it so desires.

**Corning Glass Appoints Insulator Representatives.**—The following appointments have been announced by the Corning Glass Works, Corning, N. Y., of representatives for the sale of "Pyrex" power insulators: J. E. Redmond of Phoenix, Arizona, for Arizona, New Mexico, and the El Paso district of Texas; J. Q. Lalor, Denver—Colorado and Wyoming; L. B. Graves, Minneapolis—North and South Dakota, Wisconsin, and Minnesota; A. J. Heisel, New Orleans—Mississippi and Louisiana; Wise & Braisted, Detroit—Michigan.

**Norma-Hoffmann Moves New York Sales Office.**—Announcement has been made by the Norma-Hoffmann Bearings Corporation, manufacturers of "Precision" ball, roller, and thrust bearings, that its New York sales office has been moved from the Grand Central Terminal to new and larger quarters in the Commerce Building, 155 East 44th Street. A full staff of sales engineers with increased facilities will continue to serve the Eastern territory.

**New Double Row Ball Bearing.**—The Federal Bearings Company, Inc., Poughkeepsie, N. Y., announces the introduction of a series of double row, self-aligning radial ball bearings, available in all popular sizes. One of the important features of this series is a separate ball spacer or retainer for each row of balls. This is particularly advantageous when bearings are used under conditions where the self-aligning feature is frequently brought into use. This flexible retainer absorbs much of the severe strain to which retainers in self-aligning bearings are usually subject.

**A New Electrographitic Brush.**—The National Carbon Company, Inc., Carbon Sales Division, Cleveland, announces a new electrographitic brush known as National Pyramid Grade No. 234. A unique characteristic is the non-resilient structure, enabling the brush to maintain exceptionally firm contact on commutators of high peripheral speed. It is claimed that excellent commutation, low friction and high carrying capacity combine with the smooth riding properties of this new grade to minimize brush wear and commutator maintenance. The new brush is designed especially for heavy duty, d-c. generating and substation equipment.

**Surge Diverters for Distribution Transformers.**—Coordination of the transformer insulation so that the bushing will flash over before the windings fail, gives "surge-proof" characteristics to a transformer, but naturally, when the bushing flashes over, a power arc may follow of sufficient magnitude to blow the primary fuses, according to the Allis-Chalmers Mfg. Company, Milwaukee, Wis., which announces surge diverters for application with their distribution transformers to eliminate this effect. The surge diverter has been designed to function in less than 50 microseconds so that it can be connected between the primary fuses and the transformer. This rapid action does not give time for the fuse to operate so that fuse blowings are minimized. Surge diverters may be installed outside or inside the transformer case. The flexibility in mounting makes it possible to connect the diverter either to separate ground connections or to secondary neutrals as desired.

# Trade Literature

**Instrument Transformers.**—Catalog GEA 601D, 52 pp. Describes standard lines of GEA switchboard and portable transformers; includes dimensions. General Electric Company, Schenectady, N. Y.

**Groundometers.**—Bulletin 120C, 8 pp. Describes various types of ground testing instruments, each designed for a particular class of testing. Borden Electric Company, 480 Broad Street, Newark, N. J.

**Distribution Transformers.**—Bulletin 8248-A. Describes a new distribution transformer which will not be injured by lightning surges entering either the primary or secondary windings. Westinghouse Electric & Mfg. Company, Sharon, Pa.

**Magnetic Across-the-Line Switches.**—Bulletin GEA 1568. A complete treatment of G-E control equipments of this type for every service in all sizes up to 1200 hp.; explosion-proof, oil-immersed, etc. General Electric Co., Schenectady, N. Y.

**Lightning Arresters.**—Bulletin 1, 8 pp., the first of a series describing crystal valve lightning arresters for high and low voltage transmission and distribution circuits, and for telephone and telegraph lines. Electric Service Supplies Co., 17th and Cambria Streets, Philadelphia, Pa.

**Cements and Compounds.**—Bulletin 32, 16 pp. Describes a line of cements and industrial compounds for acid-proofing, surface coating, impregnating, oil resisting, electric insulation, repairing, etc. Technica Products Company, Pittsburgh (Sharpsburg Station), Pa.

**Insulating Oil Purifiers.**—Bulletin, 20 pp. Describes the "Buckeye" hydro-volifier for purifying insulating oils. Analyses of insulating oils as contaminated by various uses and their purification by the vacuum treatment with the hydro-volifier are outlined. The Buckeye Laboratories, Inc., 510 West Ely Street, Alliance, Ohio.

**Radio Transformer.**—Bulletins 121A, 122 and 123. Describe Acme step down transformers, replacement transformers, and power transformers, respectively. These products are made principally in large quantity production for radio and allied manufacturers. The Acme Electric & Mfg. Company, 1444 Hamilton Avenue, Cleveland, Ohio.

**Small Rotary Converters.**—Bulletin and price list, 8 pp. Describes new, improved "Martin" interpole, alternating current to direct current, ball bearing rotary converters, with panels and resistances, for motion picture and general theatre use. Northwestern Electric Co., 418 South Haynes Avenue, Chicago, Ill.

**A-C. Rectifier Power Packs.** Bulletin, 4 pp. Describes "Rectopacs"—complete d-c. power packs for industrial applications to operate from a-c. lines. These B-L rectifier assemblies are used in the operation of signal systems, magnets, relays, control equipment, low voltage motors, battery charging, etc. B-L Electric Mfg. Co., 19th & Washington Ave., St. Louis, Mo.

**Power Factor Correction.**—Bulletin. Describes how power factor may be corrected through the use of static condensers in convenient unit form, assembled and mounted to meet any requirements. The bulletin contains an ingenious scale whereby the condenser capacity required for any given power factor correction may be instantly determined. Dubilier Condenser Corporation, 4377 Bronx Blvd., New York.

**Testing Machines.**—Catalog 50H, 116 pp. Describes Olsen testing and balancing machines and instruments. Such equipment is made for numerous purposes including tests for endurance, fatigue, hardness, flexibility, etc., of materials. Static and dynamic balancing machines are used by manufacturers of motors and turbines for determining armature and rotor balance. Tinius Olsen Testing Machine Co., 500 North 12th Street, Philadelphia, Pa.

**Insulators.**—Catalog 32, 320 pp. This volume is described as a handbook of reliable information for those interested in modern methods of high voltage transmission. The catalog includes illustrations, cross sections and specifications of Locke insulators. Methods of manufacture are depicted, and the history of the Locke grading shield is outlined. Included are the A.I.E.E. and NEMA Standards for insulator tests; also wire and cable tables. Locke Insulator Corporation, So. Charles & Cromwell Streets, Baltimore, Md.

# Electrical Engineering

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Downtown Cleveland from the air. Summer convention headquarters will be at the Hotel Cleveland, the nearest building of the Terminal Group which appears in the lower right hand corner of the view.

Photo by Hunter Aerial Surveys Co., Cleveland, Ohio

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NATIONAL and District prizes awarded by the A.I.E.E. for technical papers presented during 1931 were announced recently. *p. 418*

THE telephone handset, although "taken for granted" as are many of our modern conveniences, required long and painstaking research to make it a practical reality. *p. 380–383*

H. H. HENLINE, for more than five years assistant national secretary of the A.I.E.E., on June 1 became the Institute's managing executive by unanimous action of the board of directors. *p. 415–416*

POST-WAR deflation combined with a slackening of opportunity for profitable investment are held responsible for present economic conditions. This is one of the theories advanced in a progress report of a comprehensive study undertaken by a special committee of the American Engineering Council. *p. 373–379*

ALL ABOARD for Cleveland and the Institute's annual summer convention to be held in the "forest city" June 20–24! There will be no registration fee; special entertainment and sports events are scheduled; interesting inspection trips are planned; all technical sessions are to be held in the mornings. *p. 414*. Abstracts of papers to be presented are published in this issue. *p. 405–413*

WHEN planning your summer vacation don't overlook an excellent opportunity to combine business with pleasure by attending the 1932 A.I.E.E. Pacific Coast convention to be held August 30 to September 2 in Vancouver, B.C. Popularly known as the "evergreen playground" this young and progressive city and the surrounding country possess unusual recreational attractions. *p. 414*

A POWER STATION in which the development over a ten-year period had been such that the latest unit has practically five times the capacity of the first, offers a distinct challenge to the engineer; such is the history of the Waukegan generating station of the Public Service Company of Northern Illinois. Its latest installation includes a 115,000-kw. single-shaft steam-electric generator, and the first 132-kv. metal-clad switchgear ever built. *p. 391–400*

# Keep Abreast of Your Profession

By E. B. MEYER FELLOW A.I.E.E. Chairman A.I.E.E. Publication Committee

G. ROSS HENNINGER MEMBER A.I.E.E. Associate Editor, A.I.E.E.

**Can you attend six conventions a year? Can you digest 150 or more technical papers each twelve months? Can you personally meet satisfactorily the demands imposed by the continuing rapid evolution in the art of electrical engineering and its successful application? This article may reveal to you unexpectedly available facilities.**

IN A SENSE this is an anniversary month, a seemingly reasonable excuse for a bit of stocktaking. Just two years ago, May 5, 1930, to be exact, the A.I.E.E. publication committee concluded more than two years of intensive investigation, and brought forth its memorable report on "proposed changes in policy of A.I.E.E. publications." Subsequent adoption by the board of directors, June 23, 1930, converted the committee's recommendations into Institute policy, one of the tangible results of which was ELECTRICAL ENGINEERING as a New Year's greeting for 1931.

## BASIC PLAN

To provide a basis of comparison, a few of the more important points involved in the publication committee's 1930 recommendations will be outlined briefly here.

Recognizing that the Institute to keep growing must be alive to the changing requirements of its members; recognizing that the Institute's activities and publications to serve adequately must be alive to changing conditions; and recognizing that the monthly publication constitutes the main channel through which Institute members may keep informed conveniently and effectively as to current technical and professional developments and the Institute's participation therein, the committee selected the monthly publication as representing the logical field in which to pioneer the development of increased and more effective publication service to members. Out of the hundreds of letters exchanged in the publication committee's nationwide survey, the general features of a basic policy took the following tangible form:

1. Organize the editorial content of the monthly publication to serve better the needs and desires of the average individual member of the Institute.
2. Include, at least in the form of comprehensive interpretative abstracts, every paper formally presented before Institute conventions and District meetings.
3. Give special attention to the more timely papers of wider general interest.
4. Distribute to the entire membership the annual reports of the Institute's technical committees.
5. Solicit and convey to the membership special articles on timely scientific, economic, and other subjects of interest and importance to electrical engineers.
6. Reflect important contemporary developments in allied fields, and
7. Reflect more adequately the Institute's important activities, including its Section and Branch work.

In short, the assignment called for the Institute's monthly publication to carry conveniently and directly to every Fellow, Member, Associate, and Enrolled Student of the Institute a comprehensive and illuminating month-by-month cross-section of professional activities and electrotechnical developments in many related fields of endeavor.

## WHAT HAS BEEN DONE?

Comments from members indicate that for sixteen months ELECTRICAL ENGINEERING has been doing this job with increasing effectiveness. From January 1931 to and including May 1932, ELECTRICAL ENGINEERING has brought you comprehensive interpretive abstracts of 128 Institute papers, 179 articles giving you either the entire or the essential substance of an equal number of Institute papers, and 84 articles of a special character selected for their timeliness and importance and to give a better balance to the published material. ELECTRICAL ENGINEERING in these few months has reported the activities at four national conventions and six District meetings, to say nothing of almost innumerable other events of significance and importance. For those who might enjoy some interesting statistical information, the accompanying tabulation is presented.

## A REAL JOB

ELECTRICAL ENGINEERING'S relentlessly prosecuted endeavor is to serve to the greatest possible advantage the maximum proportion of the Institute's entire membership. The magnitude and complexity of this endeavor perhaps may be made more understandable by an analysis revealing the tremendously wide spread of activities in which Institute members are engaged. On the basis of the Institute's enrolment as recorded in the 1930 Year Book—17,633 Members and 2,446 Enrolled Students totaling 20,079—approximately 16 per cent are in design and manufacturing, 9 per cent in communication, 6 per cent in industry, 5 per cent in construction, 18 per cent in electric power supply, 3 per cent in railways, 6 per cent in research and education, 1 per cent in radio, 12 per cent are students, 16 per cent unclassified, and 8 per cent are in foreign fields.

For any one publication to attempt to serve exhaustively all the interests of such a widely diversified group obviously would result in a ponderous volume; for a publication to devote itself exhaustively to the interests of any one group would be to disregard the interests of the others. One of the prime functions of the Institute is to serve as a coördinating medium embracing these closely related groups of diverse interest. It is the function of Electrical Engineering to effect an interchange of information by means of which individual members may reduce the inevitable personal hazard of ever-narrowing specialization in professional practise.

### A Strong Policy

Electrical Engineering is based upon a liberal, constructive policy, and is designed with sufficient flexibility to meet effectively the constantly changing requirements of the Institute's membership. Into its policy are inculcated a bit of reticence and reserve to preserve its stability, sufficient initiative and daring to prevent its stagnation, a reverence for tradition in so far as that tradition is soundly founded and still serving a definitely useful purpose, and above all, a driving motivation to serve honestly, effectually, and unselfishly; it is edited for Institute members by a staff of Institute members whose prior industrial service has provided a solid background of experience.

**Contents of ELECTRICAL ENGINEERING for the 12 Issues of 1931**

| | Classification of Material | No. Pages |
|---|---|---|
| 1. | 137 technical articles giving the essential substance of 150 A.I.E.E. papers (also 29 interpretive abstracts of Pacific Coast and Kansas City papers) | 360 |
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### Interpretive Abstracts

One experiment has concerned the manner and form of publishing abstracts of formal Institute papers. From the earlier policy of publishing miscellaneous groups of abstracts month by month, the plan has evolved to the present practise of publishing, directly in conjunction with the meeting at which they are presented, a related group of carefully prepared interpretive abstracts. This present plan accomplishes a wide and time distribution of essential facts covered in current papers, and clears the way for a full and independent treatment of those subjects of greatest timely importance and widest general interest.

Another experiment, also initiated through the 1930 report of the publication committee, seems definitely to have come to a close. In fourteen successive issues some 1,458 "selected items" from the Engineering Index's current periodical reference service were republished. Since the complete reference service is rather widely available through the libraries of the country and through direct subscription, and since, at best, only limited space was available in Electrical Engineering, this publication experiment was concluded in the February 1932 issue.

### More for Your Money

To improve its production and distribution, Electrical Engineering recently completed an extensive and critically searching inquiry into these phases of its operations. As a result, it has transferred its production activities to a new and larger plant removed from New York's congested metropolitan area and devoted primarily to scientific and technical periodicals. Benefiting from its new and improved facilities, Electrical Engineering now brings to you in its usual 72 pages of editorial content an amount of material that previously would have required 79 pages, and should reach you several days earlier than heretofore. New paper of higher quality and softer finish now protects your eyes from the fatigue of reflected light; greater opacity improves readability. Of importance and significance in connection with these improvements is the fact that, at the same time, production costs have been reduced materially.

### Open Forum

In its present experimental "Letters to the Editor" columns, Electrical Engineering offers to the members of the Institute a readily available channel for the frank and informal discussion of almost any topic of timely interest. These columns are gaining in apparent popularity; certainly they merit attention and widespread use.

### Your Journal!

The monthly publication Electrical Engineering is well understood to be one of the Institute's most important services to its every member; therefore its publication committee and staff are determined to pursue relentlessly every opportunity to make this service more widely useful and more definitely valuable. It will continue to pioneer the way in the direction of greater and more effective publication service to Institute members; it will continue to prosecute experiments into unknown portions of the field represented by membership desires; it will make mistakes, undoubtedly, but it will not falter in its *effort* to serve. Its ambition is to be neither the first to absorb every new idea, nor the last to abandon an old one that has become out-moded.

Electrical Engineering is your publication, produced aggressively to the composite specifications of the Institute's membership. Use it! Contribute your ideas for its improvement that it may continue to serve you, and better.

## The Relation of

# Consumption, Production, Distribution

### A Progress Report of American Engineering Council*

**Council has undertaken a comprehensive study of a far-reaching problem which in one way or another undoubtedly affects every member of the Institute. In recognition of the highly controversial nature of this whole general subject, essentially the full text of a progress report is presented in ELECTRICAL ENGINEERING, without comment, but with an open invitation for comments, criticisms, and suggestions. ——The Editors.**

AMERICAN Engineering Council in January 1931 authorized the appointment of a special committee to study the relation between consumption, production, and distribution. When appointed, the committee was assigned the task of studying the following suggested points of attack relating to the balancing of economic forces:

1. Maintaining or increasing the consumption of goods and services
2. Balancing of plant, machinery, and processes against production demands
3. Balancing of distribution agencies against consumer requirements
4. Balancing of man power against production and distribution demands
5. Controlling of money and credit to satisfy the needs of government, business, and individuals
6. Encouragement of research activity to increase human well-being through development and progress in industry and business
7. Balancing of public works against public needs.

To this list has been added one other, which is involved in all of the others, and is of such importance as to demand particular study:

8. Balancing of agricultural supply with effective demands.

Economic balance obviously can be attained at widely different levels of the general standard of living. However:

> The committee has interpreted its commission as being the selection and recommendation of such governmental, financial and business policies as will maintain in the United States a standard of living that is high, broadly distributed and free from severe fluctuations.

Being acquainted with the control of the forces and the utilization of the materials of nature for the benefit of man through the instrumentality of modern technology, and realizing that this method is applicable likewise to the control of many economic forces:

> The committee believes that the objective stated is physically possible for the whole of western civilization.

This statement is contrary to the assumption revealed in much present day speaking, writing, and thinking on economic matters.

Furthermore, in view of the natural resources, the technological development, the limited degree of dependence upon foreign countries for raw materials, and other important factors which characterize the United States:

> The committee believes that in a very large degree the desired economic readjustment can be realized in the United States, even though it may be impracticable to accomplish such a purpose throughout the western world.

This thought is contrary to a large body of opinion which questions the ability of the United States to rise above world conditions.

In studying the problems outlined, the committee has not confined itself to engineering viewpoints, nor to engineering solutions. Observed similarities between engineering and economic principles are accepted as evidence of a vital relationship between the two sciences.

### PRESENT SITUATION INADEQUATELY EXPLAINED

In an effort to establish a working hypothesis, the committee endeavored to find adequate explanations for the present economic situation. As a result the committee finds the following popular explanations to be questionable and/or inadequate:

Technological unemployment
Wasteful manufacture and distribution
General over-production
Speculation
Installment buying
Breakdown of international trade and credit

**Technological unemployment** is the term commonly applied to the displacing of labor by the improvement of machinery, processes, and organization. Some have assumed that a catastrophic cumulation of unbalance from this cause is responsible for the present recession in business, but no evidence is available to prove this, and there is definite evidence to the contrary. This statement is not intended to minimize the seriousness of the problems which do arise from technological advance. At times the effect of progress *does* fall with crushing force upon individuals, business firms, entire industries, and whole communities. However, it must be remembered that technological developments

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* A progress report of American Engineering Council's committee on the relation of consumption, production, and distribution: R. E. Flanders, *chairman*, mgr. Jones & Lamson Mch. Co., Springfield, Vt.; L. P. Alford, vice-pres. Ronald Press Co., New York, N. Y.; F. J. Chesterman, vice-pres. & genl. mgr. The Bell Tel. Co. of Pa., Pittsburgh, Pa.; Dexter S. Kimball, dean, col. of engg., Cornell University, Ithaca, N. Y.; L. W. Wallace, exec. secy. A.E.C., Washington, D. C.

**"There are millions of families whose power to consume is lowered by faulty economic conditions. In the opening of the dormant markets they represent lies the greatest hope of American industry."**

have been going on for centuries; also that the normal method of adjusting the volume of production to a general increase in production efficiency has been a progressive shortening of working hours.

**Wasteful manufacture and distribution,** while of serious proportions, cannot be assigned as the primary cause of the existing unbalanced economic condition, and there is no element in its elimination that could be used for direct control of the business cycle. Doubtlessly distribution inefficiency has mitigated the severity of the problem of technological unemployment. Elimination of waste in both manufacture and distribution should be aggressively pursued because of its direct influence upon raising the standard of living and increasing leisure.

**General overproduction** is a commonly assigned primary cause for the business depression. In this point of view the committee cannot concur, although there may have been overproduction in specific industries. Individual readjustments required often are violent and even destructive, but their necessity never has been absent in good or in bad times. There is no evidence that their effects have been cumulative at this time. In view of the large increase in consumption physically possible in this country, the probability of having approached a condition of *general* overproduction is indeed remote. The real difficulty is due to the lack of a proper balance between production, purchasing power, and consumption; not to overproduction.

**"The depression which began in 1929 seems to be the recession phase of a typical business cycle occurring coincidently with a typical post-war deflation, and aggravated by a unique agricultural distress and a slackening of the opportunities for investment at a profit. This is a sound statement of the cause of the present depression because it comprehends a large area of observed phenomena."**

**The inordinate speculation** which preceded the collapse of the boom in 1929 undoubtedly was an aggravating element in the economic situation. This phenomenon and its opposite, the unreasoning panic which followed, are important psychological factors, but that they are primary causes of the business depression is doubtful. The time honored assumption that the open market is a steadying influence on prices evidently is a myth, at least in so far as the security market is concerned during periods of expansion. If the open market is to justify its existence upon the grounds that it has a steadying influence on prices, it must accomplish internal reform to bring its performance in line with this assumed purpose. Investment bankers and the speculating public both have definite responsibilities in the matter.

**Installment buying.** The wide extension of consumer credit masked the failure of purchasing power
to keep in step with production, a primary factor in
oom which ended in 1929. In the situation
reated, the normal effect of slackening de-
as delayed and the unstable balance pro-
Recovery has been hindered by the necessity for applying new earnings to the payment of goods already in use, instead of using them to move goods of current manufacture. There are, nevertheless, unrealized possibilities of usefulness in the extension of consumer credit, provided it is done in an appropriate degree at the proper time of the business cycle.

**Breakdown of international trade and credit.** No doubt the demoralized economic condition in Europe resulting from the World War has had a pronounced influence upon the economic condition of the United States. This is a serious situation. There is a growing belief that the financial and industrial operations of this country have been tied to foreign operations too closely and in too complicated a manner. Also it is believed that this situation has not been of any lasting benefit to either this or other countries. However, the breakdown need not be an insuperable barrier to recovery in this country in view of our wealth, natural resources, technical ability, and the small degree of necessary dependence on foreign commerce.

## APPARENT CAUSES OF PRESENT DEPRESSION

**The typical business cycle** is characterized by a failure of purchasing power to keep in balance with production. A classical economic theory asserts that purchasing power normally keeps in balance with production, being in its nature complementary thereto and consequent upon it. The theory holds under an ideal condition where business enterprise is neither expanding nor contracting, but is regularly paying out all it receives—provided all individuals, governments, and the like, do the same thing.

That this is not the normal course of business, because both individuals and business enterprises find necessary the saving of funds for future use, is the contention of two well-known authorities, Foster and Catchings, in their books "Money" and "Profits," and their numerous magazine articles. For a time at least, this act of saving withdraws funds from purchasing power, and thus makes it impossible for society as a whole to buy all the goods produced. This is their celebrated "paradox of thrift." The authors recognize the fact that money and credit are elastic quantities. Under some conditions they would expand them to make up for the amount withdrawn for savings.

A well-known English economist, J. Maynard Keynes, in his voluminous, brilliant, and difficult book "Money," resolves the paradox. He shows that the normal way in which savings are returned to purchasing power is through

**"Keynes says in effect that when the rate of investment exceeds the rate of savings, business improves and prices rise; when the rate of savings exceeds the rate of investment, business recedes and prices fall. This statement would have to be modified somewhat to apply to American conditions."**

the act of investment. By investment is meant new investment. Purchasing power is increased, and hence the tendency to maintain a balance between production and purchasing power is established, *if* the savings or moneys are used in investments, in new buildings, factories, homes, utilities, and other new wealth-producing activities.

As an example, it is probable that the general purchasing power of the country was maintained during the comparatively prosperous years from 1922 to 1926 by the rapid flow of millions of dollars of savings into the expanding automobile and other industries. Savings were not held out of purchasing power to any appreciable extent during that period, and thus purchasing power kept step with production.

According to another Englishman, J. L. Hobson (see especially his book "Rationalization and Unemployment") when too small an amount of the disbursement of wealth goes to those who earn wages and small salaries and too large an amount is paid those who earn large salaries and receive dividends, there is likely to accrue savings which cannot be invested profitably. In such a case the rate of savings exceeds the rate of investment and hence a business decline is initiated.

This general theory basically looks upon uninvested savings, of which there are hundreds of millions idle in the banks of the United States, as equivalent to unbought or at least unpaid-for goods. On the basis of this general theory, any increase in disbursements to the lower-paid classes is likely to broaden the market for goods. This is the American theory that good business requires high wages, a principle that the crash of 1929 reemphasized rather than disproved. However, it cannot be assumed that all money paid to American labor will go immediately into purchasing power because the aggregate volume of the savings of American workers is large.

Another important point is that the distribution of profits not supported by actual increased purchasing power gives an illusion of permanent prosperity. As a consequence, stocks rise, money flows into the stock market in preference to seeking lower returns from investment, and an uncontrolled and inevitably disastrous boom is on.

**"The grim processes of normal recovery from a depression have been described as consisting of the gradual exhaustion of uninvested savings, the writing off of bad debts, and the borrowing of money on life insurance to sustain existence."**

The grim processes of normal recovery from a depression were described by Virgil Jordan ("Economic Aspects of Stabilization," read before the American Society of Mechanical Engineers on Dec. 2, 1931) as consisting of the gradual exhaustion of uninvested savings, the writing off of bad debts, and the borrowing of money on life insurance to sustain existence. Other large scale operations of the same character and effect take place. When these painful processes of readjustment have proceeded so far that the purchasing power of the market exceeds current production and a lack of goods is indubitable, recovery commences.

Such appears to be, in its simplest terms, the nature of the typical business cycle, which in part is responsible for the current economic distress.

**A post-war Deflation** of "secular" or long term duration is the second element in the present business depression. Not the least of the miseries and injustices of war is the fact that for financing such a struggle no means have been discovered that do not involve inflation and the arbitrary and unsound expansion of the amount of money in use. All of this is reflected in a rise in the general price level and an immense stimulation of business. After a war ends, inflation normally is followed by a compensating deflation which may be sharp or gradual, controlled or uncontrolled. The United States now is experiencing the effects of the World War deflation.

**"Two similar depressions occurring in this country from 1820 to 1850 and from 1870 to 1895 were alleviated by the expansion of our western frontiers, new inventions, and the discovery of important new gold fields. Mining engineers now report that gold production is on the decline and that new strikes are unlikely."**

Deflations of the same type have occurred twice before in this country. From 1820 to 1850 there was a long-continued decline in the price level, characterized by bank failures, severe financial distress, three or four cycles of depressions, and political unrest. The discovery of gold in California in 1849 started a gold inflation, which is claimed to have started a period of recovery which lasted until the Civil War.

The second similar decline followed the mid-century wars of Europe and the United States and lasted roughly from 1870 to 1895. This period also was characterized in the United States by labor troubles, agricultural and political unrest, "greenback" difficulties, and a general retardation of business. It was in part alleviated in this country by the expansion of the western frontiers, by the development of natural resources, and by new inventions. This period was terminated by the discovery of gold in Australia, Alaska, and South Africa and the invention of the cyanide process of gold extraction.

The world now is experiencing a secular price decline arising from similar causes. In the two previous periods mentioned, the declines were arrested by new gold discoveries. The seriousness of the present situation is deepened by the fact that mining engineers feel very doubtful of any new large scale additions to the gold supply which would start a typical gold inflation; meanwhile the old mine workings are becoming less productive. The prospect is serious. Society does not prosper under a long continued deflation.

**The agricultural crisis** is typical of a post-war deflation, but in the United States agriculture is now burdened with new ills, particularly with regard to the great staples, wheat and cotton. Wheat is feeling not only the impact of the expansion of new territories, in Canada and Russia, but also that of new varieties and processes. A similar extension of areas applies to cotton raising. This increase in production has met a decrease in demand brought about by the introduction of rayon and changes of fashion in women's apparel.

This is commonplace process, but nonetheless distressful. It is one of the elements responsible for the present economic situation in this country.

**Reduced investment opportunities** conceivably may result from the apparent fact that the initial task of equipping a mechanized society seems to be past the stage of rapid growth. Is it not possible that this country is sufficiently equipped with railways, steamships, factories, and mines to meet all of its reasonable needs for some years to come? There is of course much work to be done and many improvements to be made, but is it unlikely that the past rate of acceleration of investment in mechanical equipment can continue indefinitely.

It is easy to become unduly and prematurely alarmed in this matter, but such a possibility is in the minds of many engineers. If the opportunities for new investment should decrease appreciably, prosperity on the Keynes formula would become more difficult. However, a countervailing factor is that one of the results would be a permanent lowering of the interest rate, which in turn would broaden the field for profitable investment.

> **"Remedial activities must be of such a nature that they do not require a beyond-human knowledge nor a beyond-human skill in planning, to become measurably effective. Also, they must take human nature as it is found, employing its forces and desires and giving direction instead of applying compulsion. These considerations seem to rule out most of the five-year, ten-year, and twenty-year plans which have been presented recently."**

## Suggested Lines of Action

The foregoing analysis seems to cover the nature of the outstanding elements of the present situation. As already stated, the opinions expressed are not fixedly held; but are subject to review and change. It was for the purpose of suggesting effective action that this investigation of causes was undertaken. The present economic situation is complex, and its correction may be expected to be equally complex. There is no single action which will be effective over the entire area of the mal-adjustment. Such simplification as is possible will result from keeping clearly in mind the ultimate objective: *a standard of living for the United States that is high, broadly distributed, and free from severe fluctuations.*

If one could take a position sufficiently far above the surface of the earth and were possessed of sufficient keenness of vision to see from that point what is going on in the United States as a whole, he would observe rivulets of materials leading from farm, forest, mine, and ocean gathering into broad streams in their flow toward industrial establishments. Thence he would see the finished goods, flowing in smaller streams to wholesalers, then in still smaller streams to retailers, and finally, as subdivided particles, reaching ultimate consumers. If it were visible, there would be a similar, but reverse, flow of money and credit in its various forms. The extent, variety, and complexity of these operations are beyond human comprehension or calculation.

The guiding principle which now preserves order in this complicated situation is the profit motive, although it has become fashionable to argue that this force tends to become ineffective and soon may be discarded. The real function of profit goes deeper than motive; in our economy it is a fundamental requirement for continued existence, and never is long neglected without vital peril. It is the ruling condition which, when effectively met, permits the superposition of many other less impersonal motives. Its useful function is in providing a firm foundation for structures more spiritual.

**Remedial activities.** Two recent attempts have been made to bring this incomprehensible mass of economic transactions under control. The first was made by the U. S. War Industries Board during the World War. This task was simplified by the fact that there was but one customer, the United States; one objective, the winning of the war; unlimited resources, that is, the artificial extending of credit which goes with war inflation. The mechanism which served the earlier occasion will not serve this one. The other attempt at complete economic planning is that going on in Russia. This effort also has been simplified. It is based upon an allegedly temporary low standard of living.

The American people have established a going mechanism of money, credit, labor, and services which operates to direct the flow of that complexity of goods which the "aerial observer" saw. Right now, the mechanism is not operating properly. However, in view of the complexity of the processes and the degree of success with which it has operated, the decision must surely be to study its deficiencies, improve its organization, and lubricate its movements, rather than to discard it forthwith. This being the necessary and logical decision, it would be wise to start the study by looking first at governmental and general financial policies which affect large operations and large sums of money rather than by attempting to develop means for arbitrarily controlling the flow of separate commodities. In fact, the immediate problem is to answer the question: How can the rate of savings and the rate of investments be balanced?

Taxation may be used to secure the desired balance. By increasing taxes during one phase of the business cycle, excess savings may be decreased; by floating government bonds at another phase an opportunity may be provided for investing savings. One means by which this can be accomplished is by establishing the principle of long-term governmental budgeting.

**Long-term budgeting** is one of the new mechanisms of management that has resulted from a union of engineering and financial principles, and one recognized as essential to first class business management. For the government to attempt to balance its income and expenditure in each fiscal year is not in accordance with the principles of good management. The government should recognize that in the course of a business cycle there is a time to tax and a time to relieve taxation, a time to borrow and a time to repay, a time to expand money and a time to contract it, and a time to extend operations for public works and a time to contract them.

It would appear that if, when employment has reached a certain low point, a policy were followed of borrowing for extending public works, this action would have a quick remedial effect on the business situation. By drawing them into government activities, such governmental borrowing would serve to reduce the accumulation of savings seeking investment.

The time for taxation is when business is good and profits are being made. Taxation then, if taken from profits, has the effect of reducing the amount of funds seeking investment and flowing into speculative channels. The concurrent repayment of the sums borrowed in the earlier period of the cycle tends on the whole to contract currency and thus acts as a brake on that upward movement of prices that is one of the factors building up the speculative structure of a boom.

Furthermore, it does not appear desirable to lay aside reserves in prosperous times to spend on public works in dull times. Such an accumulation of funds would be embarrassing to the necessary balance between savings and investment. In large scale governmental operations it is preferable, contrary to the accepted principles of financial morality, to borrow, spend, and repay rather than to save and then spend.

To recapitulate, borrowing, public works, taxation and retirement of borrowing applied at such times, in such degrees, and in such ways as may be found by experience to be useful, will have remedial effects on the business cycle itself. Thus dangerous accumulations of idle funds (implying unsold goods) will be put to work, credit will be extended by the borrowing operations thus tending to raise prices at a time when they are otherwise in danger of a disastrous lowering, and work will be furnished; all three at a time when they are most needed. Also, the reduction of public works, increased taxation, and the payment of loans will release men required for extending industry, prevent dangerous accumulations of money which can find no profitable use and, at a time when most needed, will restrain an hysterical rise in the price level, with all the train of disasters which follow therefrom.

These policies are not capable of immediate application, hence cannot be used in the present situation. The period of borrowing on most favorable terms has passed, the needed governmental reorganizations of public works control has not been effected, and the study needed to coordinate the program has not been given. The possibilities outlined will not become fully available except as they are worked out in preparation for the next turn of the business cycle.

**Non-competitive public works** are contemplated. If the government simply does work that private institutions or individuals otherwise would do, no new avenues for expenditure or investment are opened. *New* avenues are required if there is to be a better balance between the rate of saving and the rate of investment.

Furthermore, state governments, counties, and municipalities also must so adjust their taxation and borrowing programs as to draw their required finances from savings seeking investment, rather than from such sources as will place a burden on the operations of buying, selling, and manufacturing. This points to a general expansion of the income tax policy, both individual and corporate, with perhaps a new emphasis on earned *versus* unearned income as against property tax, sales tax, and other similar policies. Some of these latter taxes, such as that on gasoline sales, are useful and easily collected, and their elimination is not urged. However, they offer no creative possibilities such as appear in the income tax.

**Centralized national public works control,** for which American Engineering Council has been working for more than a decade, is necessary for carrying out the suggested program; likewise for the states, counties, and municipalities. While the suggested program may appear to require a larger amount of public works, borrowing, and taxation, than customary, this is not necessarily true. It is possible that no greater total expenditures will be required over the course of a single business cycle than has been customary.

**The balance of international payments** as published in the Year Book of the U. S. Department of Commerce, may be made a most valuable instrument in any system of control. This document, next to the internal balance sheet of the receipts and expenditures of the government, is the most important document prepared for the guidance of the general financial and business operations of this country.

A careful scrutiny of this balance sheet indicates that any further extension of foreign loans at this time is unwarranted on the basis of any practical possibility of increasing the counter-balancing items. A further disregard of these implications may lead to such serious involvements in foreign conditions

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**"The stabilization of money is another possibility for large scale governmental and financial action. The seriousness of the lack of control of money value (or, the general price level as reckoned on a properly selected index) is beyond the power of words to express, because the world probably is in full movement on a secular decline with only minor short-lived upturns in prospect. It is important for governments and financiers to reconsider their attitudes on this question. A steadfast attempt to discover a safe and reliable means of controlling the value of money is required. Instead of being a question that is tabooed or ignored, it should be looked upon as the most important financial subject to which those in charge of the world's money can devote their energy and attention. There should be no rest until every possibility has been canvassed."**

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as to make the recovery in this country less assured and decided, and that without compensating advantages to the world situation. The duty of those in control of the international financial operations of this country clearly lies in keeping a close eye on the balance of international payments to the end that no greater credit extensions be made than can be repaid by imports, foreign travel, and the like.

In the event world conditions should become increasingly chaotic, the organization of world finance and commerce will be best initiated in the smaller units of the national economic empires. The British Empire furnishes one such example and the United States and its dependencies another. Such limited organizations having non-predatory attitudes toward the rest of the world may offer the best hope for world progress in the immediate future.

> **"Decentralization of manufacture offers a useful method of striking a balance between agriculture and manufacturing. Only a few industries, such as that engaged in steel production, must be organized on a scale so large as to surround themselves inevitably with urban conditions. The present tendency to locate units in smaller communities should be encouraged for the sake of human as well as business values. Besides offering a greater stability to the life of the workman through the opportunity for gardens, poultry yards, and the like, it also furnishes a marginal region in which any needed interchange of manpower between manufacturing and agricultural activities could be made as changing conditions might require."**

Tools of control for the needed international flow of goods and credit lie in the government's supervision of the extending of foreign credits, and in the application of the tariff. Both the tariff and the control of credits should be viewed from the standpoint of this total situation in a way in which they do not appear to have been viewed in the past.

**The condition of agriculture** does not lend itself so readily to practical recommendations as do some of the other elements of the general economic problem that have been considered. However, to no other group would a stabilization of money be more helpful than to the farmers whom the deflation hit in full force long before it was felt by other industries. Agriculture has no inherent self-protection.

**Government reclamation policy** should be considered from now on with great care. No new areas should be brought under cultivation with public funds until every aspect of the resulting increased production has been canvassed. In fact, instead of reclaiming lands, it is possible that the government should be locating and purchasing marginal farm lands which should be reforested. This possibility already is being canvassed to some extent by the federal and state governments. It could be carried on and financed, by proper timing in the business cycle, in such a way as to improve the general situation.

**Profitable investment opportunities** must purposefully be searched out if this country actually is nearing a saturation point in mechanized equipment. Heretofore the demands for capital to supply new construction and manufacturing activities have absorbed the money available for investment.

What is there now of this same sort that will draw into profitable industry the idle millions of the years to come? Will it be the building of houses? If so, the cost of their construction will have to be diminished by new methods and by a better equalization of labor rates as between the building trades and those whom the buildings are to house, with due consideration to the annual earnings of building trades labor. When the investment market accustoms itself to a lower rate of return, capital will flow into this channel. Furthermore, the increased standard of living contemplated will enlarge the market for household furnishings, equipment, and conveniences.

Increased investment also is possible in small items totaling a large amount. Engineering analyses of the advisability of investments in new equipment by industries well established and running may well become a vital link in the maintenance of general economic prosperity in this country. The recognition of this by financial authorities and their organization to finance the multitude of small investment required may, in the aggregate, furnish a sufficient channel for investment to answer for many years the purposes of sustained prosperity. To make this effective, however, financial leaders must recognize the economics of the situation, and must consciously organize for this specific purpose. A helpful procedure would be to set up in each banking organization an engineering staff which should be as aggressive in searching for opportunities for sound investment as the sales departments have been in enlarging the lists of depositors.

This discussion again raises the question of *public works*. Herein lies an almost limitless field for the investment of private savings for public good that is socially profitable and economically stabilizing. To some extent the requirements may be realized and met by private initiative, but to a large extent it will have to be done by taxation. Moreover, it is in the interest of general business, when the rate of saving is larger than the rate of investment, to withdraw money from private hoarding and to use it for the public benefit. This is true because it is becoming plainly evident that money which is neither spent in consumption nor invested in capital goods is impotent in the hands of the one who saves. It does not benefit the saver, and it does injure society.

**Pensions,** unemployment insurance, life and disability insurance, and other similar industrial proposals deserve most careful study. The necessity, however, for such—private relief as is suggested, particularly unemployment insurance—will diminish in proportion to the success of the governmental action outlined herein.

**Trade associations** should be developed further. They should not only be permitted, but compelled to gather the basic information relating to their industries and to make public frequent and detailed reports on output, sales, stock in hand, unfilled orders, cancellations and capacity utilized. Such information would assist in planning everything that can be done industrially to maintain a steady flow of business. Ignorance of or inattention to such information in the past has resulted in entire industries adopting unwise policies which have contributed to economic unbalance. Sound methods should be developed for the introduction of new processes and machines into its field, so that industries may make needed changes with minimum economic disturbance and distress to individual workers.

Trade associations might profitably be required to set up not only standard principles and uniform methods for cost keeping, but also standard practises for financial reports to stockholders. Financial reports should be made public even though the securities of the companies are neither listed nor held by the public. Such a provision would encourage new money to flow into those fields where investment is likely to be profitable, rather than into those where a loss may be easily incurred. Associations should make a thorough, continuing study of consumer credit and installment selling. It would be most useful, at any given time, to know: whether installment buying were increasing or decreasing, whether payments were prompt or delayed, the proportion of returned goods. Information of this character would be exceedingly useful in developing policies of economic control.

**A shorter work-week** should receive the serious consideration of industry and commerce. The distribution of wealth between consumers and investors probably could be much improved by adopting new working hours and new overtime policies. For instance, it is reasonable to believe that if in an industry normally operating 50 hr. a week the working hours were shortened to 40, with 50 per cent overtime pay up to 45 hr. and 100 per cent overtime pay beyond that, the influence of the change would be in the direction of maintaining good business because:

1. Shorter normal working hours would constitute a permanent "spread of employment."

2. As business improved and the number of hours became too small, the overtime rate effective up to 45 hr. a week would assist in increasing the distribution to consuming power necessary to maintain the increased business. The extension of working time to where 100 per cent for overtime applied would add still more to consuming power.

3. The cumulative overtime would act as a damper to unwise expansion of activity. The business man would calculate more carefully before allowing rein to his enthusiasm. When he did conclude that the increased overtime was necessary his decision would be justified by the added consuming power involved.

Such a policy would have to be on an industry-wide basis, or the progressive and socially minded employers would be at a serious disadvantage.

**Employment agencies,** in a thoroughly coordinated country-wide system and with a well-trained and efficient staff, are essential. This is a pressing, unfilled need. Employment is a highly specialized problem and one of vital importance to any plan of controlling economic forces.

**Production by agreement** to reduce output, or the allocation of business to different firms is an unwise policy under normal business conditions. Such arbitrary control leads inevitably to stringent government regulation and official price fixing.

## GENERAL OBSERVATIONS

Although the issues discussed in this progress report have not been thoroughly studied, they comprise the broad outlines of the problem of economic balance, and they are subject to determination. There is an evident need for a more detailed and exhaustive consideration of them, and of others not mentioned.

Arbitrary control of modern industry and commerce in all their ramifications, complexities, and details, clearly is beyond the power of human beings; influences now at work must continue to govern its details. In particular, the profit motive and the active force of competition must be retained in such effective operation as will give society the benefit of the continuous improvement in methods and lowering of costs which they are capable of giving, but they must be restrained in their destructive and unsocial manifestations.

Since uncontrolled development has brought about so many undesirable results, there is justification for taking such chances as may be involved in developing rationally controlled economy. However, experimentation in social matters is serious, and therefore must proceed with wisdom and caution. The problem of the relation of consumption, production, and distribution is one of supreme importance and world-wide scope. There is no human problem which compares with it in difficulty, magnitude, or hopefulness. More and more, it must command the attention and devotion of the most intelligent, unselfish, and far-seeing men and women of the body politic.

> **"What is being contemplated is nothing less than the purposeful changing of the course of history. To such an undertaking the highest human capacities of our time must devote themselves."**

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Skyline of Vancouver, B. C., Host City to the 21st Pacific Coast Convention, August 30 to September 2, 1932

# Telephone Handset a Product of Research

**Many problems had to be solved before the handset type of telephone, now so popular with the public, became a practical reality. This article tells how some of these problems were solved, and how the characteristics of the present handset differ from those of the desk stand instrument.**

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ALTHOUGH the idea of mounting a transmitter and receiver on a common handle to form a handset was conceived soon after the invention of the telephone, and although handsets were in use by operators as early as 1878 only recently has it been possible to realize the convenience of this form of telephone set in the Bell system without undue sacrifice of performance as compared with the desk stand. For this reason the telephone system in this country has been built up in general around the desk stand which permitted the utilization of the available instruments to best advantage.

The greater difficulties inherent in the design of a handset as compared with a desk stand are due partly to a difference in the use of the instruments and partly to necessary differences in structure. The controlling difference in the use of the handset is due to the greater freedom permitted the user; this results in a wider range of positions for the transmitter, with a consequent tendency toward much greater variations in transmission characteristics and resistance. These variations may render the transmission unsatisfactory, and also may interfere with the operation of associated signaling and switching apparatus. The more severe handling of the handset transmitter also tends to accelerate aging.

Practically all commercial telephone sets are of the so-called "invariable" type in which the transmitter and receiver are connected to the line at all times while the set is in use. Therefore, part of the transmitter output is conducted to the local receiver; in addition the instruments are coupled to some extent through the air and, in the case of the handset, mechanically through the handle. If the amplification afforded by the transmitter is greater than the total losses in this side-tone path of receiver, air, and handle, sustained oscillation or "howling" may be set up. This condition is of course fatal to transmission; in practise it is necessary to operate well below the howling point to avoid serious transmission impairment from transient oscillations.

The handle of the handset definitely establishes the distance between transmitter and receiver: If it is too short, the user may not be able to hold the receiver on his ear with the transmitter in front of his lips; if it is too long, a transmission loss is introduced by the unnecessarily great distance between the transmitter mouthpiece and the user's lips. If the convenience of the handset is to be realized fully, the handle must be comfortable to hold and the complete handset must be light to avoid fatigue on the part of the user.

While many incidental problems have required solution during the development of the handset shown with its mounting in Fig. 1, this design is largely the result of a systematic attack upon the more fundamental problems which have been discussed. In describing the handset and its characteristics particular attention will be given to the features of importance in the solution of these problems.

## TRANSMITTER CONSTRUCTION AND CHARACTERISTICS

The transmitter is assembled in a die cast aluminum housing forming a unit which mounts in a threaded bushing in the handle. (See Fig. 2.) The molded phenol plastic mouthpiece, dome, and spacing ring insulate the electrical circuit from possible contact with the user. The carbon chamber of the transmitter is of the barrier type and differs materially from the ordinary direct-action type employed for years in desk stand transmitters. As may be noted, the diaphragm is insulated from the carbon. Both electrodes are stationary and are separated by a ceramic barrier; the electrode adjacent to the dia-

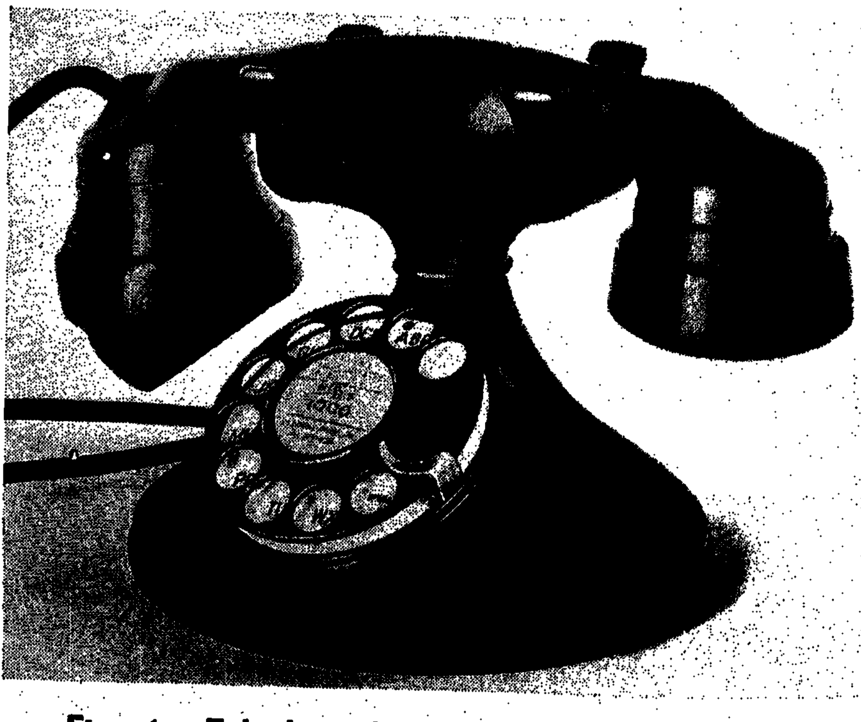

Fig. 1. Telephone handset now in use, with dial type mounting

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Based upon "The Development of a Handset for Telephone Stations" presented at the A.I.E.E. winter convention, Jan. 25–29, 1932.

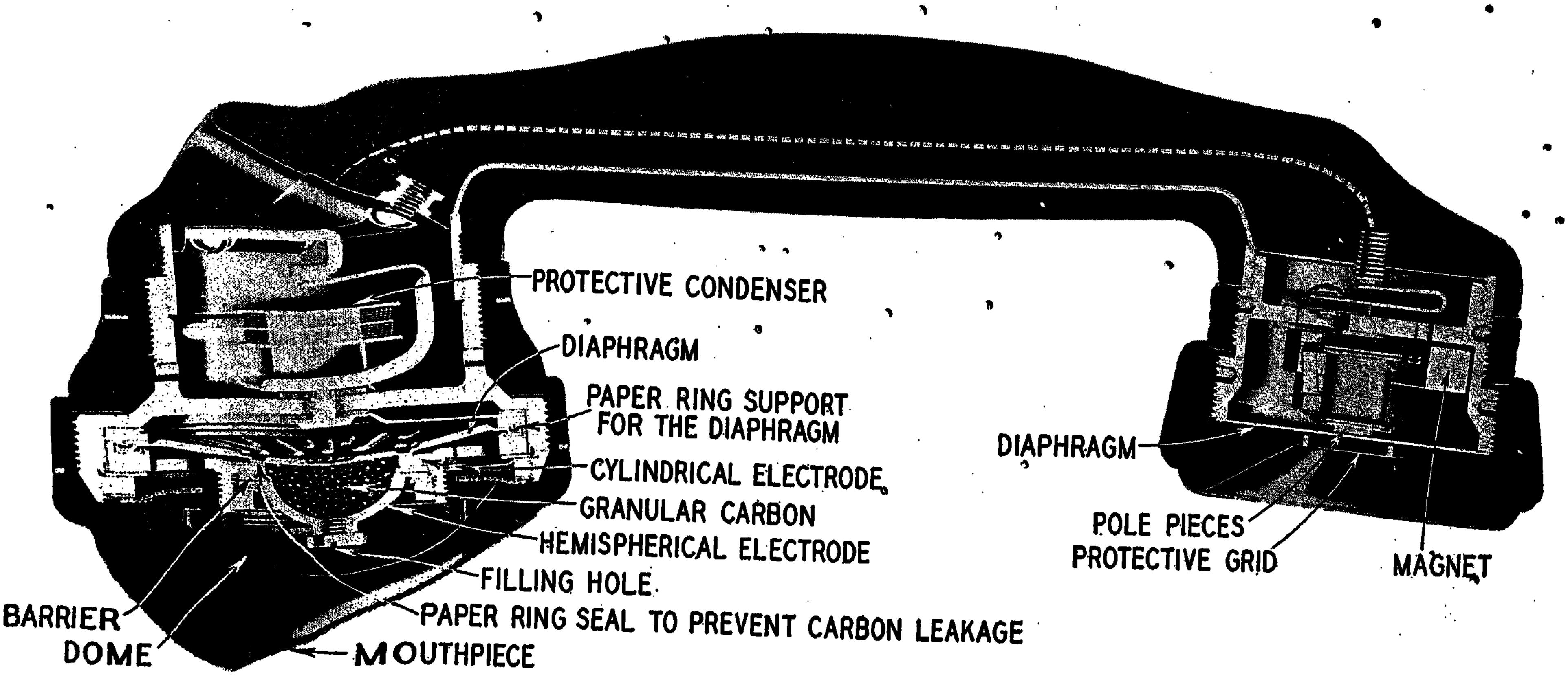


Fig. 2. Cross-section of handset

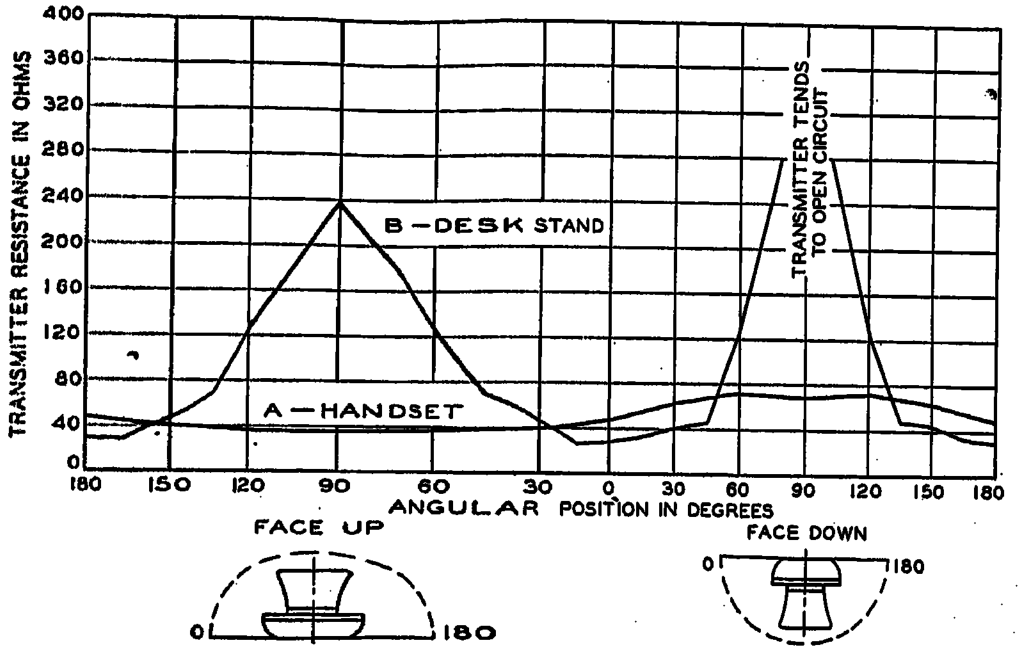


Fig. 3. Effect of position on resistance of handset and desk stand transmitters

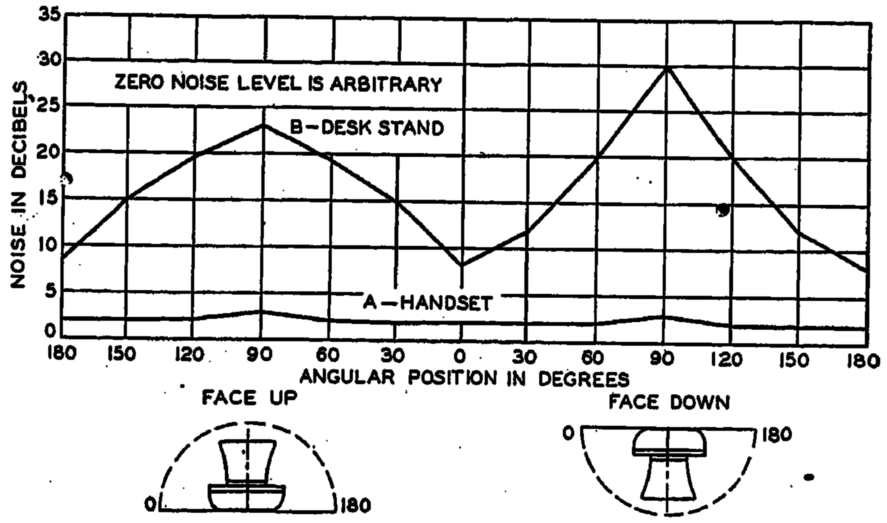


Fig. 4. Effect of position on carbon noise of handset and desk stand transmitters

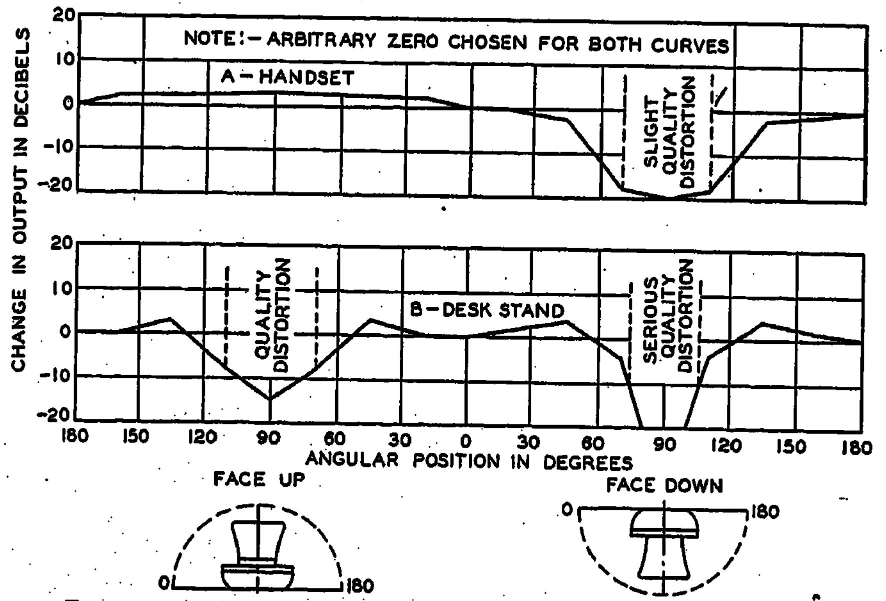


Fig. 5. Effect of position on output of handset and desk stand transmitters

phragm is cylindrical; the other, hemispherical. This arrangement insures good contact between the carbon granules and electrode surfaces, and between the granules themselves, for all of the positions in which the transmitter is likely to be held. The resultant uniformity of resistance with position as compared with the conventional form of desk stand transmitter is shown in Fig. 3.

Low and relatively uniform carbon noise results from the uniform contact pressures and resistance of the handset transmitter. It may be noted from Fig. 4 that the carbon noise of the desk stand transmitter under handset conditions would be from 5 to 30 db. greater than that of the handset transmitter.

One of the unique features of the new handset transmitter is the location of the carbon chamber in front rather than in back of the diaphragm. By this arrangement the carbon granules are held in contact with the diaphragm in all positions of ordinary use; uniform output and faithful reproduction of speech sounds thus are obtained. In Fig. 5 is shown the difference between the output obtained with this transmitter and that secured with the desk stand direct-action transmitter.

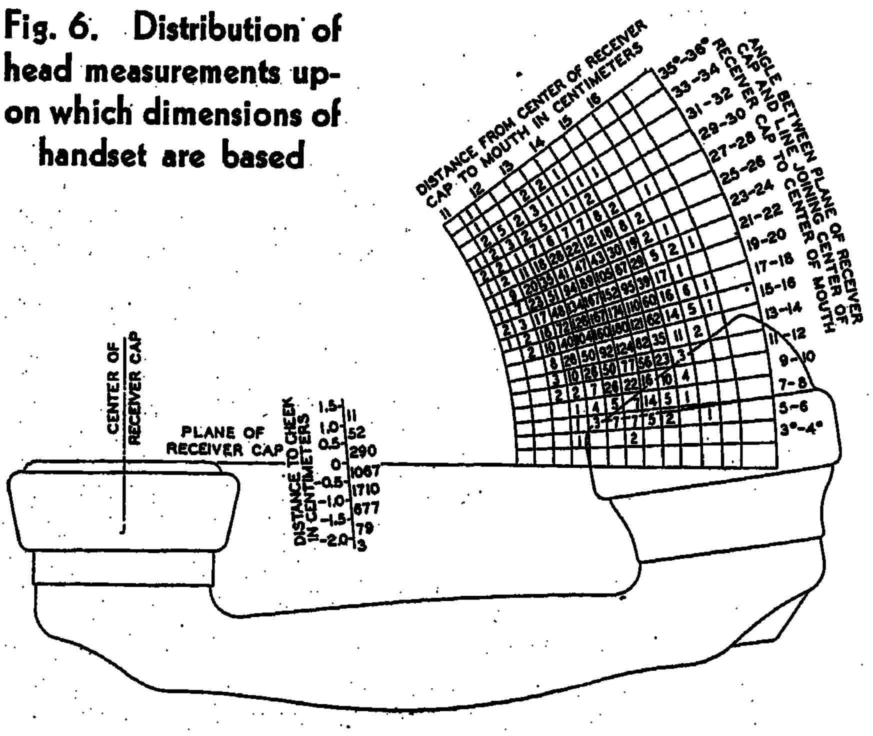
The diaphragm of the transmitter is made from thin duralumin formed into a truncated cone with radial stiffening ribs; this reduces its effective mass and provides sufficient rigidity to insure vibration as a unit throughout the operating frequency range. Several impregnated paper rings provide a resilient support for the diaphragm and add a certain amount of mechanical resistance. Appreciable improvement in response results from the lower mass and stiffness and the higher damping of the vibratory structure. Between 300 and 3,000 cycles per second the range in response is about 20 db. with this transmitter as compared with approximately 40 db. for the desk stand transmitter. A marked improvement in articulation results from this better response.

### Transmitter Aging

Characteristics of a granular carbon transmitter change with use; this is due to two principal causes the abrasive action of the granules upon each other, and the deterioration of the surface of the granules from high temperatures caused by excessive contact voltage. The former is known as *mechanical*, the latter as *electrical* aging. Aging of the desk stand transmitter is principally electrical, while in the handset it is largely mechanical.

Laboratory aging tests equivalent to about four years of handset service under severe conditions show that the change in the noise of the handset transmitter with age is of no practical importance. These tests show also that the output decreases somewhat and the average resistance increases materially during the life of instrument; the relatively small change in resistance with changes in position, however, effectively prevents the resistance from frequently becoming high enough to interfere with the operation of signaling apparatus in circuit with the transmitter. In this respect the new transmitter represents a notable improvement over earlier types.

**Fig. 6. Distribution of head measurements upon which dimensions of handset are based**



Method of filling the handset transmitter contributes materially to keeping the aging rate low. A machine taps the transmitter while it is being filled with carbon granules, so that the chamber is filled practically full instead on only about $^3/_4$ full as has been customary in the past. This reduces to a minimum the motion of the granules and changes in resistance which occur when the handset is placed on the mounting.

### Receiver

The handset receiver as may be seen from Fig. 2 is assembled in a die cast aluminum housing which screws into an insert in one end of the handle. The cap and spacing ring are of phenol plastic; they serve to insulate the electrical circuit from the user.

In general the receiver has been designed along conventional lines, but the choice of materials and design of the magnetic circuit have resulted in increased efficiency compared with the desk stand receiver. It has not been considered desirable to use this increase directly; the higher inherent efficiency of the receiver, however, is of appreciable indirect value for it has been utilized to improve the transmitting and receiving characteristics of the set, and to increase the stability of the receiver. These improvements have been effected without lowering the level of the received speech below that now obtained with the desk stand.

### Assembled Handset

Dimensions and proportioning of the assembled handset represent an effort both to meet the technical requirements and to produce a sturdy structure, light in weight and comfortable to hold, as well as attractive in appearance and in harmony with the mounting.

One of the major objections to the handset in the past has been its tendency to howl. Howling can be controlled in part by changes in the station circuit. It is desirable, however, that the handset be interchangeable with the desk stand without other changes in the telephone plant; therefore it has been designed to be inherently free from howling.

The solid phenol plastic handle employed in the present handset has a relatively high resonant frequency and provides a comparatively inefficient medium for transmitting between receiver and transmitter disturbances in the frequency range where the instruments respond most readily. Another factor in eliminating howling is found in the characteristics of the transmitter; its light and highly damped diaphragm does not respond readily to vibration set up by the receiver and transmitted through the handle, and under the worst conditions a margin of at least 15 db. against howling is realized with this structure.

Care has been taken in proportioning the handset to avoid an unnecessarily great distance between the lips and mouthpiece and to provide adequate clearance between the cheek and handle. Approximately 4,000 head measurements were made to determine the proper dimensions; these data are summarized in graphical form in Fig. 6. All but about 3 per cent of the persons measured can use the handset by holding the receiver to the ear in the usual manner; the others can do so by a slight shift of the receiver on the ear. The effect of this shift on the receiver speech is negligible compared with the average improvement in transmission resulting from the reduction in average talking distance.

## PERFORMANCE IN SERVICE

Since the initial introduction of the handset, close contact has been maintained with its performance by tests and observations under actual service conditions, and by examination of instruments returned from service. These observations have shown that, although as used by the subscriber the output of the handset transmitter to the line is somewhat lower than that of the most efficient desk stand transmitters, the improved response and articulation are adequate compensation for the lower level. Transmission performance of the handset has been found to be as good as, and probably on the average somewhat better than, that obtained with the desk stand.

Undesirable variations in transmission and resistance with change in position, excessive carbon noise, and howling, all of which heretofore have presented serious obstacles to the adoption of a handset for general use, have been overcome successfully in the design described. It has been found practicable to use this handset interchangeably with the desk stand in the existing telephone plant without important reactions on either transmission or signaling performance.

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# Commutation—

## A Switching Phenomenon

**Ideal commutation** of armature currents can **be obtained in but** very few practical cases. **In all others, a** spark occurs at both the **leading and trailing** edges of the brush, and **the introduction of** the concept of switching **assists in explaining** this phenomenon. **A brief analysis of the** various considerations **entering the problem** is given in this article.

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COMMUTATION theories usually deal with the reversal of the current in the commutating coil and with means for bringing about such reversal either along a straight line or a curve. The principal object in such studies is to accomplish commutation without excessive current densities under the brush. It is recognized that frequently it is impossible to realize this, but little attention has been paid to the fact that unless such ideal conditions are obtained, we actually have to deal with a switching phenomenon and that the problem should be analyzed with this in mind.

Let us assume that the circuit of armature coil 1 in Fig. 1 is about to be short-circuited by brush $B$ and that at this moment a voltage $e$ is induced in the coil by its rotation in the commutating field, or possibly by the stator field of an a-c. machine. It is evident that sparking in the minute point or edge of the brush $B$ which first touches the segment $a$ will be influenced largely by the speed with which the circulating current in the coil can build up as compared with the rate of increase of the area common to the brush and the segment $a$. This in turn means that the speed of the commutator will have an influence as well as the rate of increase of the circulating current. The latter is determined by the voltage $e$ and the self-inductance and resistance of the circuit of coil 1, if the coil carries no flux common to other closed circuits. This condition would exist if brush $B$ does not short-circuit any other armature coil and if the field winding $F$ is open-circuited, and under the further assumption that there are no secondary damping currents in the stator structure. Under these conditions the entire main flux $F$ and the leakage fluxes $L_a$ cause a rather high self-inductance in the armature coil 1, and consequently a slow building up of the circulating current. Fig. 2 represents a circuit equivalent to the armature coil 1 with the assumptions made so far.

The conditions change materially if the shunt winding $F$ is connected across the armature circuit as shown in Fig. 1, as well as across certain load circuits $L$ and various circuits of the generator $G$. We now have within the armature coil a leakage reactance flux $L_s$ and a mutual inductance $M$ between the armature coil and the field circuit. The latter in turn has a leakage flux $L_f$, and is closed partly through the armature circuit having resistance and inductance, and partly through several other circuits also having a resistance or inductance, or both; in other words, we have equivalent circuits somewhat as illustrated in Fig. 3. The rate of change in the circulating current now will depend upon all these factors, and therefore any change of constants in the field circuit or any of the other circuits may have a certain influence upon the commutating conditions. Similarly, any damping currents which can be induced in the solid portion of the stator yoke, or in coil

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Based upon "Commutation Considered as a Switching Phenomenon" (No. 32-33) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25-29, 1932.

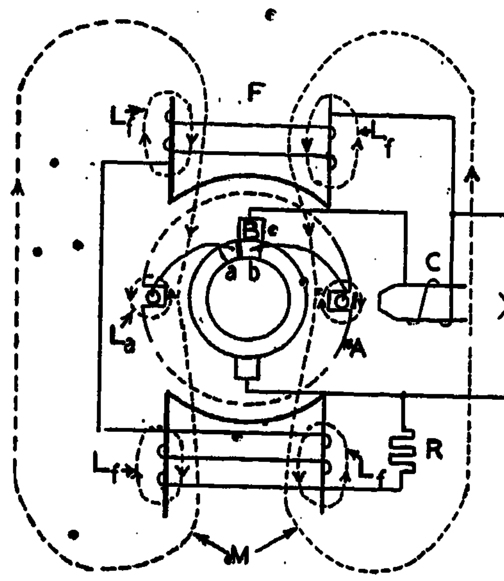


Fig. 1. Connections involved in switching theory

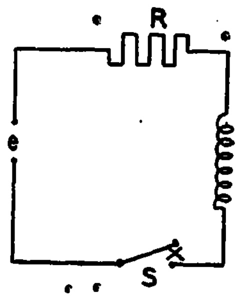
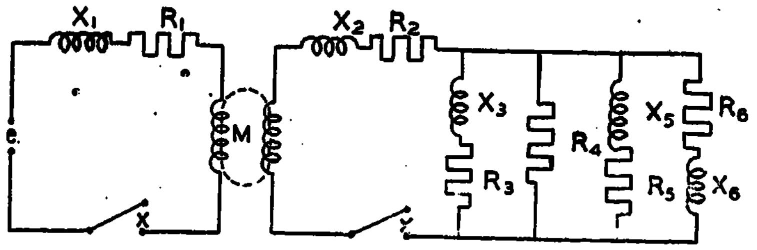


Fig. 2. (Left) Equivalent circuit of armature coil 1 shown in Fig. 1

Fig. 3. (Below) Equivalent circuit of armature and field plus external load and generator circuits



shield or damper windings surrounding the poles, may have an influence upon commutation. The various resistances and reactances shown in the secondary circuit of Fig. 3 are replaced by a single inductance $X_2$ and a single resistance $R_2$ in Fig. 4, which, while not fully equivalent to Fig. 1, somewhat simplifies the problem.

## OPENING THE CIRCUIT

All the various constants previously mentioned will have an influence also when the circuit of the coil 1 is opened while a circulating current is still flowing in it. There will be one difference, however, in that the high leakage and self-inductances helpful in the case of closing the circuit will be harmful in the opening because they considerably increase the energy to be dissipated in the spark which forms at the trailing edge of the brush. Mutual inductance, which aids in opening the circuit, as will be explained, is disadvantageous when the circuit is closed, since it allows a rapid building up of current. The effect of inductance on the opening operation may be made clear by following the switching operation in detail first for a machine with open stator circuits wound with one coil per slot, and a brush spanning one commutator bar, so that no account need be taken of mutual inductance between a commutating coil and any other closed winding. A circulating current is assumed to be flowing when coil 1 passes from under the brush.

When a circuit containing resistance and self-inductance such as shown in Fig. 2 is opened by the separation of contacts, in this case the brush and the bar, an arc or spark will be formed between the electrodes because at the last point of contact the temperature may become very high and "explosions" take place at this point, giving rise to sufficient energy density to establish the cathode spot of an arc on the negative electrode. As the contacts separate further the arc becomes longer and finally becomes unstable and vanishes. Any calculation of the decrease to zero of the circulating current due to commutator bars passing from under the brush must consider this short arc or spark formed. The arc characteristic, *i. e.*, the arc voltage as a function of the current through it, depends on the arc length. The latter in turn is varying and depends upon the way in which the arc is lengthened as a function of time; in other words, upon the speed of the commutator.

If the transient arc characteristic for a particular condition is known accurately, the energy dissipated in the arc can be calculated. This energy may be divided into two parts; the energy stored electromagnetically in the circuit, and the energy supplied to the circuit for the duration of the arc. In the case of the commutating coil, the latter energy may be supplied by the voltage induced in the coil by its rotation in the commutating field, or in an a-c. machine it can be induced also by transformer action between the stator field and the coil. Usually the total arc energy will lie between the values of once and twice the energy stored in the magnetic circuit. This stored energy varies directly with the self-inductance coefficient $L$ and the square of the current to be broken; hence the arc energy also depends upon these factors. The length of time during which the arc or spark is present also increases with an increased coefficient of self-inductance. Since a trailing edge spark is harmful in so far as it burns the commutator and brushes, it is desirable to keep the energy to be dissipated in the spark as low as possible. This can be done by lowering the self-inductance or reducing the current to be interrupted; also by the proper utilization of mutual inductance.

## EFFECT OF MUTUAL INDUCTANCE

As previously indicated, circuits having mutual inductance with a commutating coil are established by the field or stator circuit being closed through the armature and other circuits, or by damping currents in the stator structure. Other circuits having mutual inductance with the commutating coils usually exist if the winding is chorded, if there is more than one coil per slot, or if a wide brush is used; in fact, whenever the sides of at least two coils which are being commutated during a common time interval lie in the same slot. In this case the mutual inductance between coils must be considered. For example, if the brush is wide as shown in Fig. 5 and short-circuits the two armature coils 1 and 2, coil 1, which is about to be open-circuited, still has leakage fluxes $L_1$, but it also has mutual fluxes $M$ with the field winding as previously described, and mutual fluxes $M_a$ with the armature coil 2, the latter in turn having leakage fluxes $L_2$ of its own.

This may better be shown by the simplified although not fully equivalent circuit indicated in Fig. 6.

If such a circuit containing mutual inductance in addition to self-inductance and resistance is opened with a switch, the decrease of the current in the primary circuit again may be calculated if the transient arc characteristic curve is known. It is found that in this case all of the stored energy need not be dissipated in the switch. The decrease of current in the primary circuit will induce voltages in the secondary circuits such as to cause their currents to change. This means that part of the energy stored in the primary circuit may be transferred to the secondary circuits and dissipated as $I^2R$ loss in them or held in storage in the secondary circuits. Consequently, the energy dissipated in the spark may be, and usually is, reduced by introducing mutual inductions. The magnitude of the reduction depends upon the degree of mutual coupling between the circuits and upon the circuit constants, such as resistance and self-inductance, of all the circuits having mutual inductance with the commutating coil. It follows therefore that as conditions in the stator circuits change, the commutating condition may change also, although such factors as load current, speed, and commutating fields, which are usually considered as the only ones determining the commutating conditions, remain unchanged.

For similar reasons, different conditions of mutual inductance between the various armature coils will have an appreciable influence. The conditions of the mutual flux $M_a$ and leakage fluxes $L_1$ and $L_2$ in Fig. 5 will of course be appreciably different when the coils are located in separate slots than when the coils are located in the same slot. This difference leads to the frequently observed condition that certain commutator segments show more burning than others. These considerations also explain why frequently a split-throw of the armature coils improves commutation as a result of its effect upon the relation between leakage and mutual inductances of the coils. Without the split-throw a good transfer of energy from coil to coil in the same slot may take place, but the last coil in the slot is not well coupled to the first coil in the next slot; hence considerable energy must be dissipated when the circuit of the last coil in a slot is broken. The split-throw reduces this maximum dissipation of energy in the spark because at least one coil side of the coil under commutation is always closely coupled with another coil side; and assuming that the brush is wide enough to short-circuit the adjacent coil, better transfer of energy can take place. The beneficial effect thus produced consists not only in decreasing the maximum sparking but also in bringing about more uniform sparking on the different commutator bars, which in turn reduces irregular wear and differences in the heating of the bars; irregular heating of the bars if occurring to any marked extent is likely to cause differences in expansion of the bars and therefore mechanical irregularities in the commutator surface, with consequent further accumulative harmful effects upon commutation.

In all of the previous discussions upon the constants of the circuits which may influence commutation, only resistance and reactance have been mentioned. However, with the high frequencies of commutating currents, it is quite possible that at times certain capacity effects in the various circuits may exert an influence upon commutation conditions.

Having established the new concept of switching and the fact that the various machine and external circuits may have an influence upon commutation, a means has been found for explaining many other practical experiences which cannot be explained by the conventional commutation theories. It may be seen readily, for instance, that there may be a difference in commutation between shunt, series, or separately excited machines, between laminated or solid field structures, etc., although the speed, current, and commutating field are the same. It follows that in the case of a-c. commutator machines the commutation may be affected by the size and type of transformer to which the machine is connected and by various other factors.

Interesting results may be obtained with two series-connected motors on a motor car, especially in a-c. motors having no damping effects in their field structure. If in such a case the commutating impulses transformed into the fields of the two motors are exactly in opposition, no damping current can flow in the fields. Such opposition of voltages will occur if the relative position of the two commutators is such that the brush edge in one motor lines up with the mica insulation while in the other motor it happens to be in the center of the bar. If the relative commutator position changes so that the brushes in both motors will have the same position with regard to the mica insulation, the commutating impulses reflected in the fields will be in phase and damping current can flow, thus causing conditions entirely different from those previously mentioned. With two such motors on a motor car having slightly different speeds caused by a difference in the wheel diameters, periodic variations of commutation will take place. With the two motors connected in parallel across the same transformer, similar variations may take place. Even a change in design from

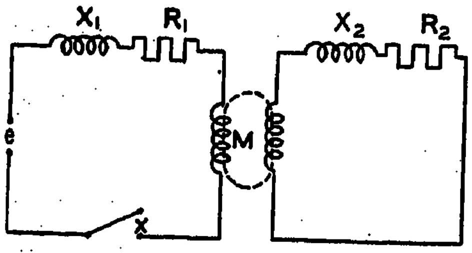


Fig. 4. (Above) Simplified diagram of the equivalent circuit shown in Fig. 3

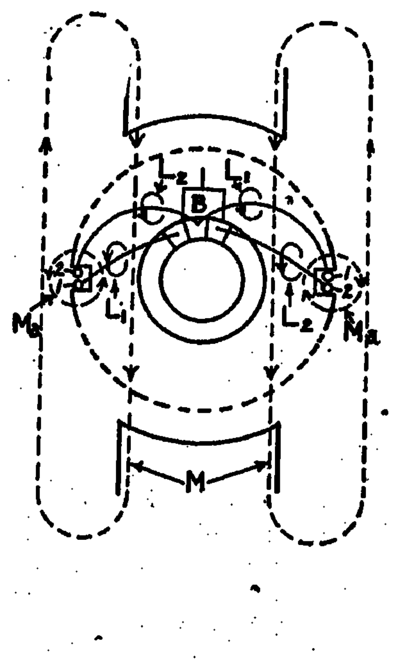
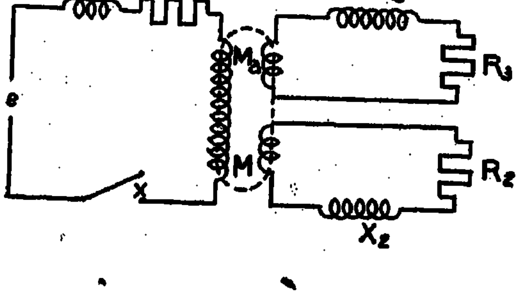


Fig. 5. (Right) Armature connections with two coils short-circuited by one brush

Fig. 6. Simplified equivalent circuit of Fig. 5



series to parallel connected fields in the motor may influence commutation. With such machines as phase-advancers or regulating machines connected to the secondary of induction motors, the switching theory readily explains differences in commutation which have been observed by the authors for different connections of such machines to various external circuits.

The introduction of the switching concept into the commutating problem is of course not necessary when ideal commutating conditions exist. There also are cases which approach the ideal sufficiently to make the consideration of the switching concept unnecessary in practise. Again, where the commutating conditions are not ideal but where the brush short circuits several armature coils, their mutual effect may be so predominating that the characteristics of the field and external circuits may have little influence. In general, however, the commutating phenomenon cannot be considered as completely analyzed unless the possibility of the switching phenomenon as influenced by the various circuits has been given due consideration.

# Cathode Drop in Arc Discharges

**There is no general agreement among physicists concerning the mechanism which produces a low cathode drop with the correspondingly high current density which is characteristic of an electric arc. Herewith is presented a review of prevalent theories regarding this phenomenon, and results of some experiments on arc and glow discharges.**

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AN ARC is defined as an electrical discharge in a gas or vapor in which the cathode drop is of the order of 10 or 20 volts and the current density to the cathode spot is of the order of hundreds or thousands of amperes per square centimeter. In order for an arc to exist it is necessary that there be some mechanism for producing electrons at or near the cathode. As to the way in which these electrons are liberated there are three theories as outlined briefly in the following paragraphs.

1. Thermionic emission. This, the oldest theory, assumes that by the bombardment of positive ions the cathode spot is maintained at such a temperature that it is capable of emitting sufficient electrons to maintain the arc. For this to take place temperatures greater than 3,000 deg. cent. would have to exist at the cathode spot. These temperatures actually do exist in the case of the carbon and tungsten arc; but in arcs between less refractory metals such as copper or brass as well as in the mercury arc, no such temperatures are present at the cathode spot. In such cases thermionic emission cannot account for the liberation of sufficient electrons to maintain the arc.

2. A more recent theory is that positive ions are present close to the cathode in such large numbers that they produce an electric field sufficiently large to free electrons from the cathode by the attraction of the field alone. Calculations show that electric fields of the order of $10^6$ volts per cm. exist at the cathode in the case of both copper and mercury arcs; these fields are large enough to supply the electrons necessary for maintaining the arc.

3. A third theory proposes that the production of electrons is due to thermal ionization of the gas near the cathode. In order that there should be any appreciable thermal ionization in the gas, the temperature of the gas must exceed 4,000 deg. cent.; it is doubtful if such a high temperature obtains.

It seems probable therefore in the case of arcs between highly refracting electrodes, such as carbon and tungsten, that electrons are emitted from the cathode by thermionic action. In the case of arcs between less refractory electrodes such as copper or brass, electrons probably are emitted from the cathode by the action of the intense electric field existing at the cathode surface.

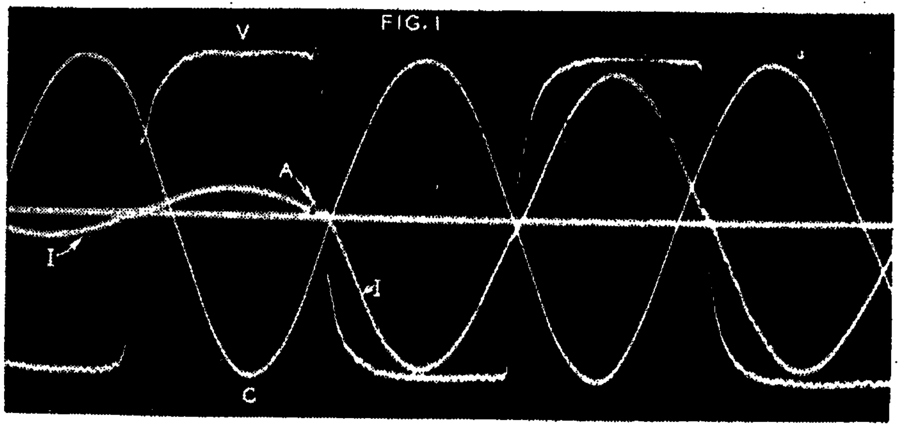

**Fig. 1. Current and voltage relations in the abnormal cathode drop; at point A the current was increased suddenly from 52 to 320 milliamperes**

## NORMAL CATHODE DROP IN THE GLOW DISCHARGE

In the glow discharge a much higher cathode drop exists than in the arc. If the current density to the cathode is below a certain definite value, the cathode drop is constant and is spoken of as the normal cathode drop. As the current density to the cathode is increased further the magnitude of the cathode drop increases, and the region over which it extends decreases. When the cathode drop increases with increasing current density it is spoken of as the abnormal cathode drop.

In the glow discharge as in the arc there must be some mechanism present to produce electrons at or

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Based upon "Cathode Drop in Arcs and Glow Discharges" (No. 31M5) presented at the A.I.E.E. Pacific Coast convention, Lake Tahoe, Calif., Aug. 25–28, 1931.

near the cathode; the following theories have been proposed:

1. Positive ion bombardment of the cathode. It is known that electrons may be liberated by positive ion bombardment of a metal surface; however, when the normal cathode drop obtains it is doubtful if the positive ions hit the cathode with sufficient energy to produce any appreciable ionization; but when the cathode drop is abnormal, the positive ions possess much more energy, and under these conditions this mechanism may be the most important one.
2. Production of electrons by collision of positive ions with neutral gas molecules in the region of the cathode drop. In general this process occurs only when the positive ions possess energy greater than in the normal cathode drop.
3. Production of electrons from the cathode by photoelectric effect. It is believed generally that this process is inadequate to account for the required number of electrons necessary to maintain the discharge.
4. Production of electrons by metastable atoms arriving at the cathode. Because one of the electrons is in a high-energy level, these metastable atoms have enough potential energy to free electrons from the cathode. It is probable that in the case of the normal cathode drop this mechanism is important, especially when the rare gases such as helium, neon, or others are used.

Unfortunately, so far none of these theories has been developed so as to obtain quantitative agreement with experimental results. It is possible that two or more of these processes may take place simultaneously; also in some cases one of them may be most important, whereas in other cases another may be more prominent.

## Abnormal Cathode Drop

As the current to the cathode of a discharge tube is increased in the region of the abnormal cathode drop, the magnitude of the cathode drop increases and the distance from the cathode in which the cathode drop exists decreases. Both of these effects cause an increase in the electric field existing in the cathode drop. It is quite certain that as the current is increased, a greater portion of the current to the cathode is due to electrons leaving the cathode.

For the past several years considerable experimental work has been done on the abnormal cathode drop; the results of a few of the experiments are presented here. Preliminary measurements of the cathode drop, especially when the current to the cathode was large compared to that required to just cover the cathode with the cathode glow, gave quite inconsistent results. The first measurements were made with direct current, but soon it was found better to use alternating current and measure the cathode drop with an oscillograph.

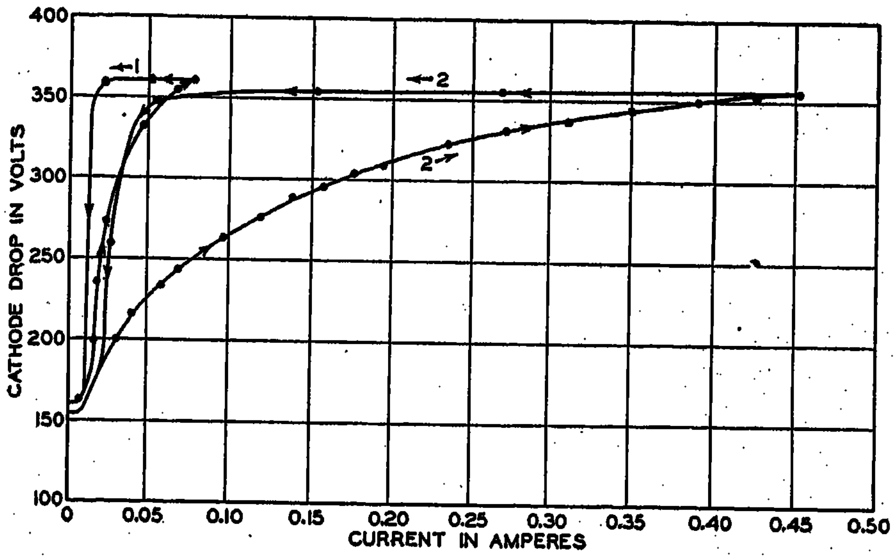

Fig. 2. Voltage of Fig 1 plotted against current

In Fig. 1 is an oscillogram which shows the relation between current and voltage in the abnormal cathode drop. Curve *I* represents the current through the tube, *V* the voltage across the tube, and curve *c* a calibration curve which in this discussion may be disregarded. At point *A* a resistance in series with the tube was short-circuited so that the current was increased from 52 to 320 milliamperes (r.m.s.). It is apparent at once that this change in current has only a small effect upon the voltage curve.

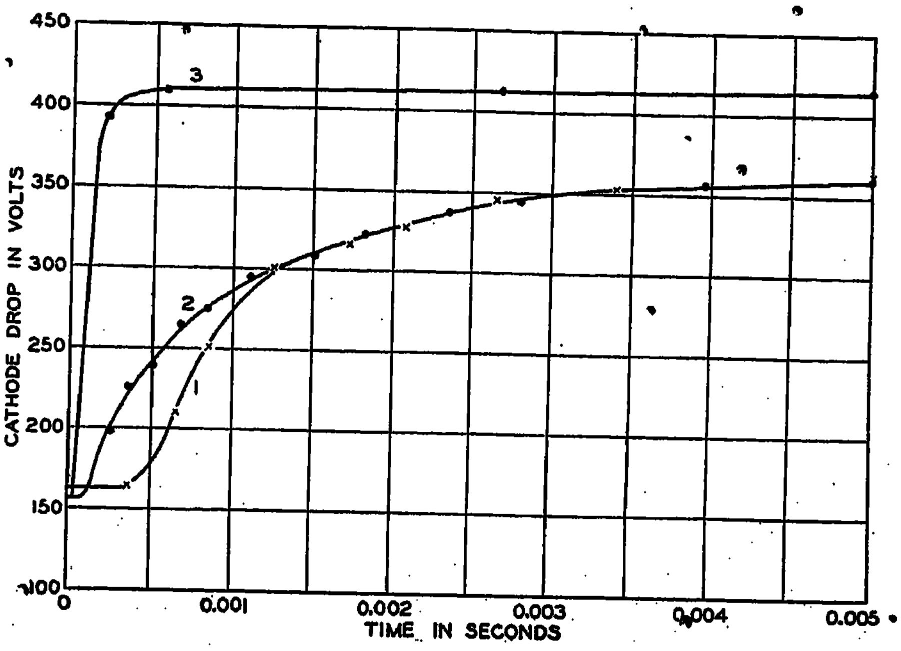

Fig. 3. Voltage of Fig. 1 plotted against time

In Fig. 2 the data from Fig. 1 are plotted with voltage and current as ordinates. This curve shows that the cathode drop is less for increasing values of current than it is for decreasing values. In Fig. 3 the data from Fig. 1 are plotted with cathode drop and time as ordinates. Curve *1* represents the data for increasing current when the effective value of the current is 52 milliamperes; curve *2* for a current of 320 milliamperes, and curve *3* for a current of 4 amperes. The difference between curves *1* and *2* for low values of time can be explained by the fact that the abnormal cathode drop occurs at an earlier time when the current is high than when it is low. If allowance for this is made it is apparent that the cathode drop requires approximately the same time to build up in the two cases where the current is 52 and 320 milliamperes, respectively. Curve *3*, however, shows that the cathode drop builds up much more rapidly when the current is high; this difference is explained as follows: In the case where the current is low, the cathode drop is formed by the positive ions from the main body of the gas congregating near the cathode, a relatively slow process. When the current density to the cathode is high, the cathode drop is due to the ionization of gas molecules near the cathode caused by electrons leaving the cathode and by the rapid dispersion of electrons away from the neighborhood of the cathode. Since electrons move hundreds of times more rapidly than positive ions, this latter process takes place much more rapidly. This leads to the conclusion that when the current density is high, a large part of the current to the cathode is carried by electrons leaving the cathode.

### TRANSITION FROM GLOW TO ARC

The transition from a glow discharge to an arc is illustrated by Fig. 4. When this transition occurs, the voltage (curve *V*) shows a sudden decrease which corresponds to the decrease in cathode drop. Current through the tube is represented by curve *I*; its effective value was 4 amperes. The fact that sometimes an arc is formed and sometimes not, probably is due to the fact that the surface of the cathode is constantly changing because of the rapid sputtering or disintegration that occurs in the glow discharge with such high current densities.

A consideration of results from several oscillograms similar to Fig. 4 leads to the following explanation of the process by which a glow discharge changes to an arc: As the current to the cathode is increased in the glow discharge, a larger portion of current is due to electrons leaving the cathode; these electrons are not emitted uniformly from the cathode surface, but come primarily from small portions of the cathode, which because of some impurity are especially active. These electrons produce ionization in the region of the cathode drop, this ionization being greatest in the vicinity of the active spots. Due to their high mobility, the electrons leave this region much more rapidly than do the positive ions. A high space charge results, increasing the electric field in the vicinity of these active spots as well as the number of electrons emitted therefrom. This process is cumulative and proceeds rapidly until the electric field near one of the spots increases to an amount sufficient to produce electrons from the cathode by the attractive force of the field alone. When this occurs, an arc is formed with its low cathode drop and extremely high current density to the cathode spot.

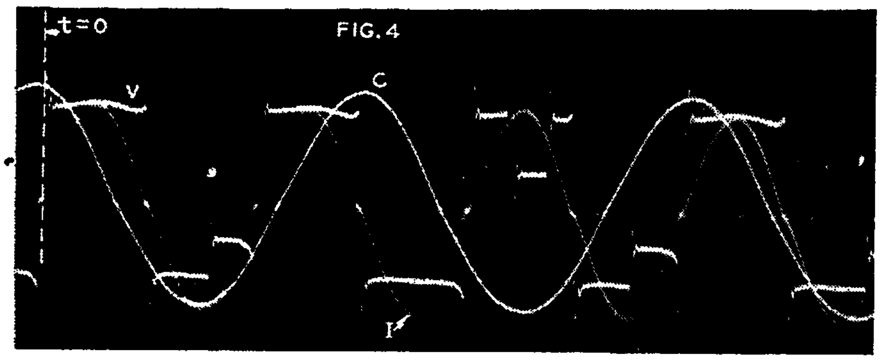

**Fig. 4. Current and voltage relations during transition from glow to arc**

This explanation is based upon arcs at low pressure; it is probable, however, that the same process is effective at atmospheric pressure, and occurs every time the current in an a-c. arc passes through zero, except when the electrodes are so refractory that they can support a high enough temperature to produce a large electron current by thermionic emission.

# Transient Oscillations in Coupled Windings

**A mathematical study of the oscillations occurring in a pair of mutually coupled windings, the primary and secondary of a transformer, when one of the terminals is subjected to the impact of a traveling wave, has been completed. The general conclusions reached in this study are summarized in the following article.**

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IN THE PAST, the mathematical analysis of transient oscillations in transformer windings has been based upon a single winding having self-inductance and mutual inductance between its turns, capacitances along the stack and to ground, and in one instance, resistances to represent the losses. Such a circuit ignores the presence of secondary circuits, but, strangely enough, proves quite adequate to describe the internal high-frequency transients of the winding under consideration, not only qualitatively, but quantitatively as well.

Cathode ray oscillograms, however, do show some difference in the characteristics of the oscillations, depending upon the terminal connections of the secondary circuits. This is particularly true in the case of an isolated neutral primary winding, where a change from an open-circuited to a short-circuited secondary may bring about considerable changes in the frequencies of oscillations. This shift of frequencies has been attributed loosely to a change in the effective inductance of the circuit, brought about by closing the secondary circuit; just as the natural frequency of a simple lumped inductance-capacitance series circuit is changed if the inductance is reduced by short-circuiting a coupled winding. In addition to the above limitation of the single winding theory of transformer oscillations, there was nothing in the equations relative to the internal oscillations of the secondary circuit.

The complete idealized circuit of a two-winding transformer is shown in Fig. 1. The primary winding, on which the traveling wave is assumed to impinge, is designated as winding 1, and all associated voltages and currents have the corresponding subscript as $e_1$, $i_{c1}$, $i_{k1}$, and $i_{L1}$. The secondary winding is

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Based upon "Transient Oscillations of Mutually Coupled Windings" (No. 32-4) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25-29, 1932.

designated as winding 2. The terminals are shown connected to impedances $Z_1$, $Z_2$, $Z_3$, and the incoming surge impedance $Z$. Each winding has capacitance $C$ and $K$ to ground and along the stack, respectively, and an effective self-inductance $L$. The two windings are coupled magnetically by an effective mutual inductance $M$, and electrostatically by capacitance $C_3$. It is pertinent to remark at this point that the effective inductances of the circuit include the partial interlinkages, on certain assumptions, and are not simple, uniformly distributed constants. The necessity for these more complicated assumptions is responsible for greatly increasing the complexity of the problem.

The application of Kirchhoff's laws to the elements of the circuit shown in Fig. 1, permits the partial differential equations of the circuit to be written. A solution then is found such that the terminal and boundary conditions are satisfied.

The initial distribution caused by the impact of an abrupt wave front depends only upon the capacitance elements of the circuit, because the currents through the capacitive paths are infinite for an infinite rate of change of voltage, whereas the currents in the inductive paths are all zero at that first instant. Thus the circuit which is effective for calculating the initial distribution may be simplified by eliminating the inductances shown on Fig. 1.

The idealized circuit of Fig. 1 is free of losses, and therefore stabilization does not occur (theoretically) unless the terminal impedances have losses. For zero or infinite values of the terminal impedances the oscillations never do subside, but persist forever. However, any actual circuit possesses some losses, and consequently the oscillations eventually die out and the currents reach permanent values, so that there is no change of flux and there are no induced voltages. The distribution of voltage in the primary winding is then uniform, ignoring the conductance from the winding to ground, and the potential of the secondary is constant throughout the winding. Thus while the realization of these final distributions is contingent upon the presence of losses, either in the circuit itself or in the terminal impedances, nevertheless there are fixed axes of oscillation about which the transient oscillation of the no-loss circuit take place.

The complete solutions have not been attempted, except for zero and infinite values of the terminal impedance; that is, for grounded and isolated terminals. The solutions which have been worked out are also restricted to rectangular, applied waves. The response to waves of arbitrary shape can always be found in the usual way by an application of Duhamel's theorem, as described in a previous paper, "Transient Oscillations in Distributed Circuits," by L. V. Bewley, A.I.E.E. Trans., v. 50, 1931, p. 1215–33. The solutions are in the form

$$e = \text{(final distribution)} + \Sigma \text{ (harmonic space and time oscillations)}.$$

The time harmonics are always *cosine* functions, and since Duhamel's theorem is operative only on the *time* functions of the solution, the response to different arbitrary wave shapes may be written down by inspection from the corresponding solutions given in the previous paper, where the time functions were also harmonic *cosine* oscillations.

## CONCLUSIONS AND FINDINGS

As far as a description of the transient in the primary winding is concerned, both qualitatively and quantitatively, it is not necessary to consider the influence of the secondary winding beyond keeping in mind that its terminal conditions will change the relative importance of the natural frequencies of oscillation. But these changes in frequency can be accounted for quite adequately by changing the effective inductance in the equations.

The transient in the two-winding circuit consists of an infinite series of space and time harmonics, oscillating about the final distribution as an axis of oscillation. The amplitudes of these harmonic oscillations depend upon the initial and final distributions, and are in fact given by the Fourier analysis of the difference between them.

The space harmonics which appear in the solution are decided by the Fourier series chosen to represent the initial distribution throughout the length of the winding. The fundamental wavelength upon which the Fourier analysis is made is dictated by convenience in any specific case, and is therefore more or less arbitrary. Thus for certain terminal conditions, a full range *cosine* series may prove the most appropriate, while in another case a half range *sine* series may lead to the greatest simplification.

To each space harmonic there correspond two distinct time harmonics; that is, each space harmonic consists of two components vibrating at widely different rates. The amplitudes of these two time

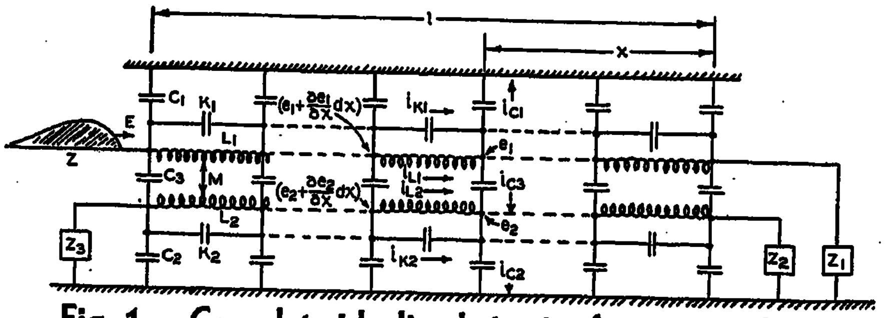

**Fig. 1. Complete idealized circuit of a two-winding transformer subjected to high frequency transients caused by an incoming wave**

$C_1$ = capacitance of primary winding to ground
$C_2$ = capacitance of secondary winding to ground
$C_3$ = capacitance between primary and secondary windings
$K_1$ = capacitance between ends of primary
$K_2$ = capacitance between ends of secondary
$L_1$ = effective self-inductance of primary
$L_2$ = effective self-inductance of secondary
$M$ = effective mutual inductance between windings
$Z$ = surge impedance of line at primary
$Z_1(p)$ = grounding impedance of primary neutral
$Z_2(p)$ = terminal impedance of secondary, neutral end
$Z_3(p)$ = terminal impedance of secondary, line end
$E$ = terminal voltage of primary due to traveling wave
$p$ = $\partial/\partial t$ = partial time derivative
$t$ = time
$i_{c1}\ i_{k1}\ i_{L1}\ i_{c2}\ i_{k2}\ i_{L2}\ i_{c3}$ = currents through $C_1$ $K_1$ etc.
$e_1$, $e_2$ = instantaneous voltages at any point $x$ of primary and secondary, respectively
$x$ = fraction of total winding from neutral end
$l$ = 1 = total length of winding.

harmonics are usually quite different, but by a change of terminal conditions, it is possible to change their relative importance.

The harmonic frequencies of the secondary circuit are the same as those of the primary winding, but the amplitudes bear a ratio to the corresponding amplitudes in the primary which depends upon the order of the space harmonic. In other words, there is no fixed proportionality between the oscillations in the two circuits.

The oscillations corresponding to an infinite rectangular applied waves start simultaneously throughout the windings, and the time harmonics are all *cosine* functions. The response to applied waves of arbitrary shape can be obtained by an application of Duhamel's theorem.

# Coordination of Line and Transformer Insulation

**The coordination of transformer insulation with line insulation recently has been discussed widely, and sentiment has changed gradually in favor of the use of an air-gap for purposes of coordination as against the practise of reducing the line insulation near the substation. Standards of dielectric strength and air-gap spacing in accordance with this trend are presented herewith.**

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AT THE Toronto convention of the Institute in June 1930, a paper "Recommendations on Balancing Transformer and Line Insulations on Basis of Impulse Voltage Strength," by V. M. Montsinger and W. M. Dann, A.I.E.E. TRANS., v. 49, 1930, p. 1478–81, sponsored by the transformer subcommittee of the electrical machinery committee, was presented to bring before the membership the status of certain work done by the subcommittee in connection with the coordination of transformer and line insulation.

Two things of interest and importance were included in this paper: first, a recommended practise of expressing the impulse strength of a transformer in terms of the 60-cycle dry flashover of suspension insulators; and second, recommendations for coordinating the impulse strengths of the transformer and the line insulation. These recommendations included either the use of a safety gap of known flashover characteristics connected in parallel with the transformer, or the reduction of the line insulation to a coordinating value for a distance of half a mile from the transformer, or a combination of either with a suitable lightning arrester.

Since the publication of this paper the principle of coordination has been discussed widely and it appears to have become accepted in a general way throughout the industry. It seems, however, that there has been a gradual change in sentiment in favor of the use of an air-gap for purposes of coordination, as against the practise of reducing the line insulation. Several reasons have contributed to this shift of sentiment. For example, the idea of having a flashover occur out on the line, even though restricted to a distance of half a mile, seems to be unacceptable to operating engineers, and opinion seems to favor having the flashover occur at an accessible point near the transformer. Any degree of line over-insulation made desirable by local conditions in the vicinity of the station becomes feasible if the coordinating gap is used. Furthermore, a string of insulator disks if used for coordinating purposes affords less chance for a reasonable adjustment of coordinating values. The removal of one disk, for example, from a string of eight, causes a change of approximately $12^{1}/_{2}$ per cent in the impulse flashover value. The difficulties of adjustment naturally are even more pronounced with shorter strings. In contrast with these difficulties, air-gaps may easily be set for any desired degree of adjustment.

The transformer subcommittee has recognized the growing sentiment in favor of a gap for coordinating purposes, and it is the purpose of this brief progress report to bring to the attention of the Institute membership the following revisions which have been made in the previous recommendations.

## IMPULSE STRENGTH OF TRANSFORMERS

The yard stick used to express the impulse strength of a transformer has been changed from the 60-cycle flashover value of a given line insulator to a coordinating gap with a given length in inches, as outlined in the following paragraphs:

(*a*) *Transformers Receiving Standard Tests as Specified in Par. 13-400, A.I.E.E. Standards No. 13.* Apparatus conforming with the standards of dielectric strength should be so designed that its impulse strength against lightning is greater than the impulse flashover voltage to earth of an air-gap whose spacing is in accordance with Table I. This spacing is between the ends of two square-cornered, square-cut, co-axial rods not more than $^{1}/_{2}$ in. thick and so mounted that the rod overhangs its support at least one-half the gap spacing. The insulators used as supports should meet the N.E.M.A.-N.E.L.A. 60-cycle flashover requirements for the line voltage.

(*b*) *Transformers Receiving Other Than Standard Test.* For trans-

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Full text of "The Coordination of Transformer Insulation With Line Insulation" (No. 32-64) which is to be presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932, and is sponsored by the transformer subcommittee of the electrical machinery committee: V. M. Montsinger, *chairman*, W. H. Cooney, W. M. Dann, H. C. Louis, Basil Lanphier, L. C. Nichols, George Vaughan, F. J. Vogel.

formers receiving a test different from that given for the rated circuit voltage in (*a*) the gap spacing should correspond to the test which the transformer will receive, in accordance with the relation between test and gap spacing given in (*a*).

### RECOMMENDATIONS ELIMINATED

The "Recommendations for Coordinating Transformer Insulation with Line Insulation in the Field," included in Part II of the Montsinger-Dann paper of June 1930, will be eliminated from the recommendations of the subcommittee. These recommendations involve the three methods of coordinating transformers with line insulation referred to in the opening paragraphs of this report. The coordinating gap replaces the eliminated recommendations and serves the following purposes:

1. It establishes the standard of impulse strength required in the design of a transformer.
2. In practise, it limits the magnitude of incoming surge voltages to values less than the impulse strength of the transformer, thereby establishing coordination.
3. A lightning arrester may be used in conjunction with the coordinating gap to prevent system outages.

**Table I—Air-Gap Spacings**

| Rated Circuit Voltage | Transformer 60-Cycle Test Voltage | Spacing of Air-gap |
|---|---|---|
| Kv. | Kv., r.m.s. | Inches |
| 13.8 | 28.6 | 4.25 |
| 23 | 47 | 6.25 |
| 34.5 | 69 | 9.25 |
| 46 | 93 | 12.25 |
| 69 | 139 | 18.75 |
| 92 | 185 | 25.00 |
| 115 | 231 | 31.5 |
| 138 | 277 | 38.25 |
| 161 | 323 | 44.5 |
| 196 | 393 | 54.5 |
| 230 | 461 | 64.0 |

# Development of the Waukegan Station

**The reasons for the development, choice of site, and general plan of the Waukegan station are outlined briefly in this article. The three major periods of development are covered, the article serving as an introduction to the two companion articles "Waukegan Features New Electrical Design" and "A 115,000-Kw. Turbo-Alternator," which follow.**

By
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THE WAUKEGAN station of the Public Service Company of Northern Illinois is located approximately 40 miles north of Chicago at the extreme northeast limits of the city of Waukegan on the west shore of Lake Michigan. This station, with an installed capacity of 290,000 kw., performs the dual function of supplying energy to a metropolitan system and to a surrounding transmission system.

During the year 1916, in giving consideration to load development and corresponding facilities for generating capacity to take care of this load, it became increasingly evident that the future demands for electricity in the Chicago metropolitan district would require substantially larger power station developments than had been considered heretofore. It was evident also that it would be necessary to locate such developments on Lake Michigan where an unlimited supply of condensing water was available.

As a result of these conclusions, a careful survey was made of all suitable power station sites, bearing in mind those fundamental requirements of adequate water supply, transportation facilities, expansion space, rights-of-way for disposing of energy generated, and proper correlation with respect to the load area to be served. This survey revealed that the power station sites most suitable for development to supply the Chicago metropolitan district were at Waukegan on the north, and at the Illinois-Indiana state line on the south. In the intervening distance of 50 miles along Lake Michigan no other suitable sites were adequate or available.

On the southern site the initial development of the commonly known State Line station of the Chicago District Electric Generating Corporation has taken place. The northern, Waukegan, site was acquired in 1917. The original site comprised 87.6 acres with 1,223 ft. of shore line on Lake Michigan. This has been increased since to a total of 198 acres and 3,249 ft. of shore line The site could be served from two good coal-bearing railroads with a possibility of harbor development, and was suitably located for the acquisition of private rights-of-way to dispose of the large volume of energy it was proposed to produce. A private right-of-way 250 ft. wide was acquired. This connects with its three branches consisting of a 135 ft. southerly right-of-way to Chicago, a 150 ft. northerly right-of-way

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Based upon "Development of the Waukegan Station of the Public Service Company of Northern Illinois" (No. 32M9) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14-16, 1932.

to Milwaukee, and a 150 ft. westerly and southerly right-of-way which surrounds the Chicago metropolitan area.

At the time the site was acquired, it was thought that the first transmission lines for carrying bulk energy would be at 66 kv. and possibly a 132-kv. development could be expected later. It was fortunate that by the time the initial station development took place it was practical to proceed with 132-kv. transmission with its corresponding increase in capacity.

### INITIAL DEVELOPMENT PERIOD

Ground was broken for the initial development of the station on August 23, 1922, and the first unit of 25,000 kw. capacity was placed in service October 11, 1923. Unit 2, for 35,000 kw., was placed in service April 6, 1925. Both units 1 and 2 operate at 350-lb. pressure with a total temperature of 675 deg. fahr. with no reheat. Three boilers serve each unit. These boilers are equipped with chain grate stokers, and it is of interest to note that this was the first successful application of alternating current to variable speed individual stoker drive, the speed variation being approximately 40 per cent with a flexibility about equal to that obtainable with d-c. motors. Generation is at 12 volts, kv., the switching equipment consisting of the conventional cell type construction with a Cory system of interlocks.

At this period of the development it was thought that the ultimate capacity of the station would be of the order of 200,000 or 300,000 kw.

### SECOND DEVELOPMENT PERIOD

Unit 3, of 50,000-kw. capacity, went into service June 22, 1927. The operating steam pressure was raised to 600 lb. with a total temperature of 725 deg. fahr. A radical change in the type of electrical equipment was made with the installation of this unit, this change being the first complete installation in this country of metal-clad switching equipment for power station service.

For years electrical engineers of this country had considered metal-clad equipment but believed its development unsuited to American capacities and conditions despite the fact that it had been used extensively and successfully in England for many years. Naturally enough, the first installation carried with it some grief. However, the experience gained suggested future improvements and demonstrated the practicability of this type of switching equipment with its many inherent advantages over the conventional open type installation.

The continued results obtained with the metal-clad switchgear on unit 3 were so universally satisfactory from engineering construction and operating considerations that the exclusive use of this type of gear was adopted as a policy for all future power station and substation installations or additions.

A few of the outstanding advantages of metal-clad switchgear are:

1. Hazards to personnel are eliminated almost completely.
2. The carrying on of construction work is simplified and expedited.
3. Almost complete salvage value is obtained when the growth of the system compels replacement.
4. Costs are no more when all factors, including building structures switch cells, and bus compartments, are taken into consideration.

Unit 4, of 65,000-kw. capacity, was placed in service May 10, 1930. The use of pulverized fuel was decided upon prior to the installation of this unit. A thorough investigation was made of existing installations and a decision was reached to adopt the unit system with ball and table type mills. The operating steam pressure and temperature is the same as for unit 3 with the exception that an important change in the steam cycle was instituted. Steam is bled from the turbine at approximately 200-lb. pressure from the thirty-second row of buckets and reheated to a total temperature of 725 deg. fahr. One of the three boilers supplying the unit is of the reheat type. Generation continued at 12 kv. similar to the three previous units and, continuing the policy referred to above, metal-clad switchgear was used as on unit 3. Following is a tabulation of station performance for units 3 and 4 for the month of July 1931, using southern Illinois coal with a moisture content of approximately 13 per cent:

| | |
|---|---|
| B.t.u. per lb. of coal | 11,469 |
| B.t.u. per kw-hr. output | 13,299 |
| Lb. of coal per kw-hr. output | 1.16 |
| Monthly load factor (per cent) | 44.1 |

### THIRD DEVELOPMENT PERIOD

Unit 5 of 115,000-kw. capacity went into service September 1, 1931. With the installation of this unit an important departure was made in the switching arrangements. The generator bus was eliminated and the generator, together with its 120,000-kva. transformer bank stepping up to 132 kv., were considered as a unit, all switching being done at 132 kv. Again in accordance with the policy previously referred to, metal-clad switchgear was used. The use of this equipment on the 132-kv. installation marks the first of its kind in the world.

A further investigation of pulverized fuel mills led to the use of the tube type unit mills on unit 5. While this type of mill requires more power than the ball and table type mill, particularly during light load operation, it was thought that the maintenance problem would be simplified. These mills have not been in operation long enough to determine definitely characteristics of flexibility of operation or to make a general comparison with the ball and table type mill. Each of the three boilers supplying this unit is served by three mills with a capacity of 25,000 lb. of coal per hr., respectively. The steam cycle is similar to unit 4, steam being bled from the thirty-first row of buckets for reheat to 750 deg. fahr. One of the three boilers on unit 5 is equipped for reheat.

With the addition of unit 5 bringing the station capacity up to 290,000 kw., it was considered advisable to supplement the coal handling system with a rotary car dumper. This installation is unique in that the complete system, including the mule haul which pushes the loaded cars up an incline to the dumper, was developed for a-c. operation.

Application of a-c. motors to individual variable speed stoker drive and to coal handling equipment came about as a result of a policy adopted in 1906. It was felt that in order to stimulate the development of a-c. flexibility it would be advisable for the company to insist upon the use of a-c. equipment and to share with the manufacturer the grief and expense certain to be encountered in such a development. The experience derived from each case, while somewhat unpleasant at the time of development, has resulted in the complete and successful adaptation of a-c. drive to the various pieces of equipment considered. This in turn has been decidedly helpful to the power sales organization.

### FUTURE DEVELOPMENT

The present station capacity of 290,000 kw. covers what was thought to be the complete development at the time the first unit was installed in 1923. A definite prediction at this time as to the ultimate development of the Waukegan station would be to place one in the tenuous position of all prophets. However, it would appear far safer to predict a figure of 1,000,000 kw. than 500,000 kw. Bearing this in mind, it was necessary to give serious consideration to transmission facilities for future station output. The earlier 132-kv. circuits to Chicago were designed for approximately 90,000-kva. capacity and consisted of 300,000-cir. mil conductors. The latest circuit installed in 1930 consisted of 750,000-cir. mil conductors with a carrying capacity of approximately 180,000 kva.

A station which in its development over a 10-year period finds its last installed unit practically five times the size of its first unit, certainly offers a challenge to the engineer—a challenge to coordinate the successive developments so as not to nullify any preceding investment and at the same time to take advantage of the developments in the art to obtain an efficient workable station as a whole. Waukegan station, it is felt, meets these requirements.

# Waukegan Features New Electrical Designs

**Three new electrical developments incorporated during the last development period of Waukegan station are described in this article. They include the first 132-kv. metal-clad switchgear ever used, a 115,000-kw. single-shaft turbo-alternator the rotor of which was the largest forging ever made in this country, and a coal-car mule for which a new scheme of a-c. drive was developed.**

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THE THIRD and most recent development period at the Waukegan station of the Public Service Company of Northern Illinois includes two outstanding features: namely, the first 132-kv. metal-clad switchgear ever used, and a 115-kw. single-shaft turbo-alternator.

During the previous development periods, described in the preceding article "Development of the Waukegan Station," an open type steel structure for 132-kv. switching had been installed which included a number of rather unusual features, due partly to the fact that it was necessary to conserve space in one direction, whereas there was ample space in the other direction. As the main bus is located above the other equipment in the middle of the structure, it appears that there are three buses. However, the line and transformer buses are connected so that they form a rectangular ring bus with the main bus in the middle. The line and transformer reserve buses may be sectionalized by means of an oil switch of load-break disconnecting switches.

### 132-KV. METAL-CLAD SWITCHGEAR

The 132-kv. metal-clad switchgear consists of two double-bus units installed as shown in Fig. 1. One of these units is for switching the high voltage side of the 120,000-kva. transformer bank supplied by generator 5, and the other is for a 132-kv. transmission line. The buses of these two units are connected to, and form an extension of, the main and reserve buses in the open type steel structure. These two double-bus switchgear units are arranged as indicated in Fig. 2, and consist of oil filled cable buses and interconnections, special motor driven disconnecting switches enclosed in metal housings, oil switches equipped with potheads instead of outdoor bushings, and special bus connections and disconnecting devices for the instrument transformers.

The switchgear is rated to carry 1,200 amperes and the oil circuit breakers will interrupt 2,500,000 kva. at rated voltage. The capacity of the buses may be increased to 2,400 amperes by installing another set of buses. The present buses consist

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Based upon "Electrical Design Features of Waukegan Station" (No. 32-57) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932.

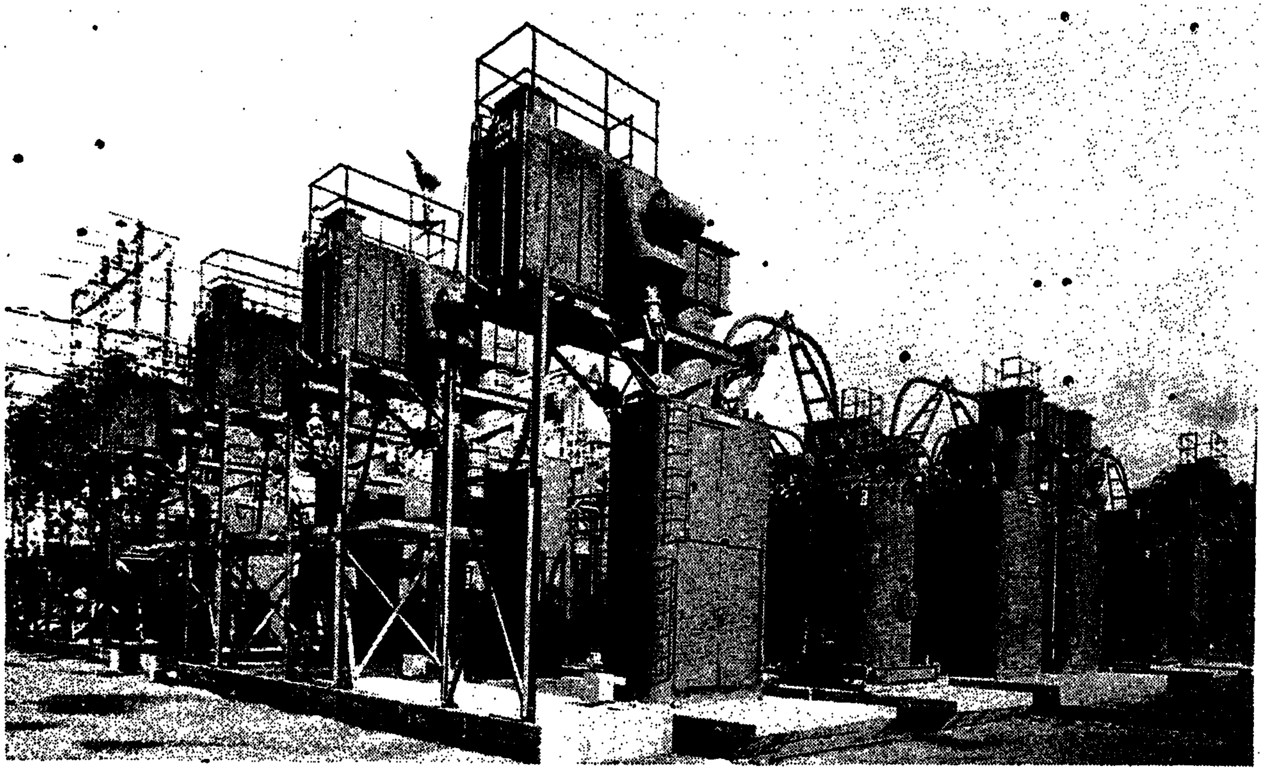

Fig. 1. The 132-kv. metal-clad switchgear, part of unit 5 installation, is the first ever used

of 3,020,000-cir. mil, oil-filled, paper-insulated, lead-covered, copper-armored cable. Isolated racks support the bus cable about 9 ft. above the switchgear foundations as it loops from switchgear unit to switchgear unit. The ends of each of these bus cable loops are insulated, and the midpoint of each cable sheath in each loop is grounded to keep the induced voltage in the cable sheath at a minimum.

The disconnecting switch consists of contacts in an oil filled tank equipped with entrance bushings which in turn are enclosed in an outer housing. The tank as well as the bushing on the bus side is raised and lowered by a motor driven mechanism, and overtravel is prevented by limit switches. When the tank is lowered, the circuit is opened under oil and the bus contact on the entrance bushing withdraws from its bus receptacle, thus providing a visual separation which through a sight glass may be observed from the outside of the housing. The bus receptacle consists of a hollow porcelain shell that forms a part of the main structure into which the entrance bushing on the disconnecting switch tank enters. The opening in the lower end of this porcelain shell is automatically covered by a metal cover when the disconnecting switch is withdrawn. These switches are operated in groups from the oil circuit breaker control panel, or individually at the disconnecting unit.

As it is seldom necessary to disconnect a potential transformer, this disconnecting device is not motor operated. A portable motor, however, has been provided for raising or lowering the potential transformer "coupler" tank whenever necessary.

A number of interlocks is provided to prevent operating errors and to protect personnel. For instance, one of the interlocks prevents the opening of the upper door in the disconnecting switch house until the disconnecting switch is opened; this causes the shutter which prevents access to live parts to close. Another interlock prevents operation of any or all disconnecting switches on both sides of the circuit breaker unless the latter is open. This interlock is effective on each disconnecting switch on individual operation as well as on group control. The circuit breaker cannot be closed unless all the disconnecting switches on both sides of the breaker are fully open or completely closed. An interlock also prevents operating any of the line disconnecting switches unless the line cable test switches are open. Conversely, no line cable test switch can be operated until line disconnecting switches have been opened. An interlock also prevents the lowering of any potential transformer coupler tank unless the ground switch and test switch on that phase are closed. An interlock also prevents opening any ground switch or test switch until the potential transformer coupler tank is in the connected position; this is accomplished by means of a system of Cory locks.

### 115,000-Kw. Generator

The generator which is tied into the 132-kv. metal-clad switchgear equipment is a 115,000-kw. single-shaft unit, designated as unit 5. A description of its mechanical details is included in the companion article, "A 115,000-Kw. Turbo-Alternator," which follows. This unit generates at 18,000 volts and with its 120,000-kva. transformer bank constitutes an operating unit without an intervening bus. The generator leads are tapped to supply the 10,000-kva. auxiliary power transformer, and the high voltage and low voltage switchgear units provided for this transformer are tripped by differential relays in case internal trouble develops, so that interference with the generator operation is avoided.

### Auxiliary System

The low voltage side of this 10,000-kva. auxiliary power transformer is connected to the main 2,400-volt station auxiliary bus which can be sectionalized by units, or can be operated as one bus. Reactors are provided between sections of this bus for fault current control. Power for starting the auxiliaries on units 3, 4, or 5, or for emergency operation in case one of the station auxiliary transformers is out of service, is obtained from the auxiliary bus.

The capacity of the auxiliary power transformers

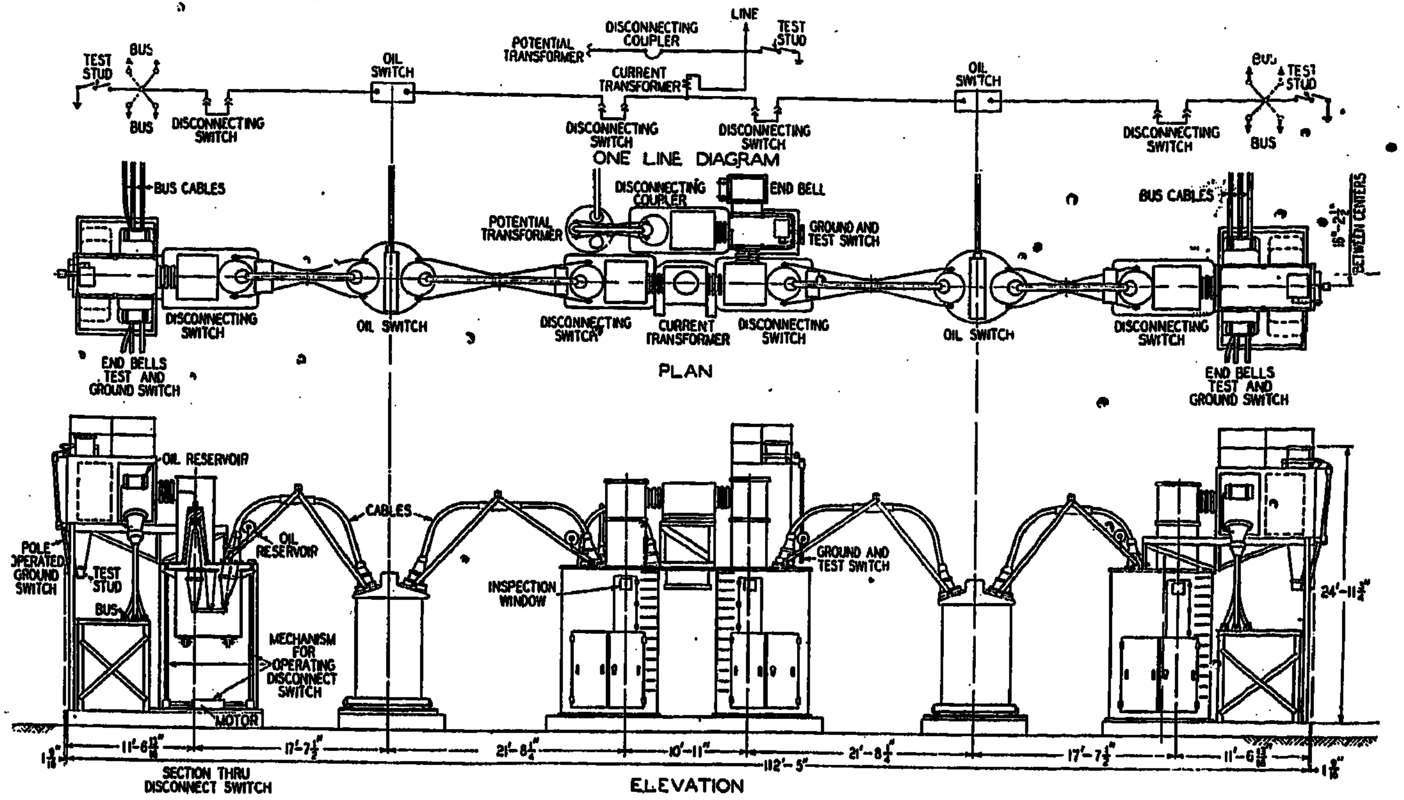

Fig. 2. Layout of one phase of the 132-kv. metal-clad switchgear

in the present installation is 9.4 per cent of the generator capacity, the active and reserve transformer capacity being 7.4 per cent and 2 per cent, respectively. These are selected so as to give under normal demand conditions 20 to 30 per cent unused capacity in each transformer.

GENERATOR FIELD CONTROL

Instead of using generator field rheostat and a common excitation bus, as was provided for the first four units, a main and a pilot exciter have been provided on the shaft of unit 5. On this unit the generator voltage is controlled by means of the main exciter field rheostat, thus resulting in a considerable saving due to the elimination of generator field rheostat losses. In addition, a much more rapid and flexible method of controlling the generator is provided, and in case automatic voltage control is later considered advisable, it can be provided easily at a comparatively small additional cost.

Although the use of a common excitation bus as installed for the first four units provides reserve capacity, it was felt that the expense of reserve excitation was not justified for unit 5 because the latter must be shut down in order to repair either exciter, and because, in addition to the reliability of present-day exciters, the main exciter will operate self-excited, thus making it possible to operate without the pilot exciter.

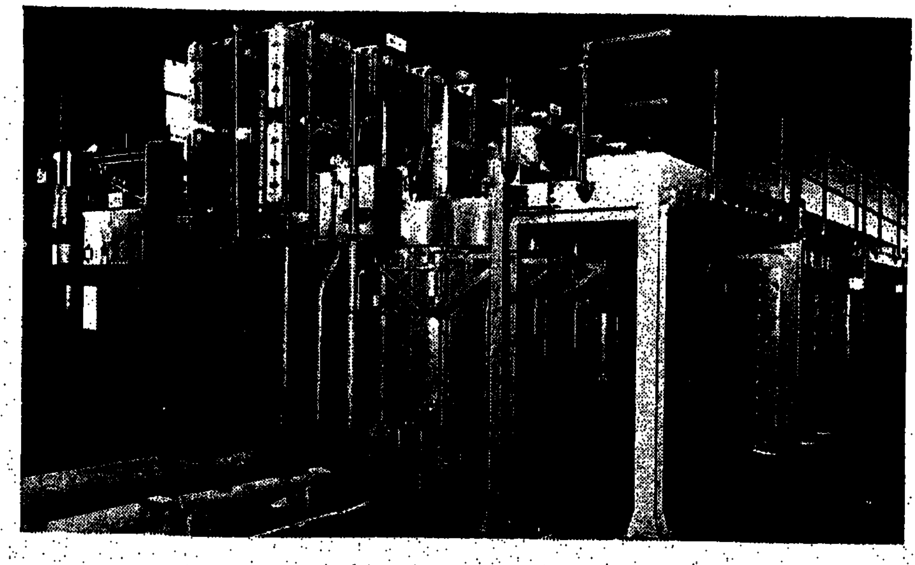

Fig. 3. The 12-kv. metal-clad switchgear used in the second development period

GENERATOR CABLES AND POTHEADS

On the unit 5 installation four single-conductor, 3,000,000-cir. mil, paper-core, 25-kv., paper-insulated, lead-covered cables are used for each phase. These cables extend from the generator to the 120,000-kva. transformer bank in fiber ducts. This 16-duct bank was designed in the form of a square surrounding a large square tile placed in the center of the duct bank to permit air circulation, thus equalizing the internal and external temperatures of the ducts.

Special care in design was used to make the cables carry equal load currents and to avoid injurious sheath voltages. The cable phases in the ducts have been so arranged that the electromagnetic fields surrounding the cables tend to neutralize each other, thus equalizing reactances and avoiding reductions in carrying capacity.

As it was considered more economical to have induced voltages on the cable sheaths than to suffer the losses due to induced sheath currents, cable-sheath insulators were placed at the ends and at about the midpoint of the 550-ft. fiber duct run, thus dividing the cable sheaths into two sections. These two cable-sheath sections are grounded at their midpoints, thus making the induced sheath voltage too small to affect the lead cable sheaths injuriously. Oil filled potheads as well as oil filled joints have been used on the cables for unit 5, as an added safety feature which should insure maximum reliability in service.

On the small power cable the very expensive conduit runs which were needed to protect cable of the ordinary type from mechanical injury have been eliminated and instead, armored cables laid in troughs suspended from the ceiling are used.

As a result the cost of these cable installations has been materially reduced.

### A-C. Car-Mule Drive

One of the recent additions to the coal-handling system at this station is the coal-car mule, which pushes the loaded cars up an incline to the rotary car dumper. The special service requirements of the car-mule drive would normally dictate the use of d-c. motors, but as direct current has not been necessary for the other auxiliaries except for control purposes, it was decided to avoid its use for this device, if possible. Accordingly an a-c. system was developed which is, perhaps, the first of its type used in this country. Solution of the problems of securing large variations in torque with large variations in speed, of obtaining a flexible control system, and of taking the slack out of the hoisting cable to prevent breakage when the load is suddenly applied, have made the use of a-c. motors possible.

The essential feature of this installation is the use of a slow, two-speed, 440-volt, high-torque motor. Coupled directly to the torque motor is the 500-hp., 2,300-volt, wound-rotor, main driving motor. The drive shaft to which the motors are coupled is geared to the car-mule cable hoisting and lowering drum.

The control system of the equipment which pushes a loaded coal car up the incline is complex, but to hoist a car automatically it is only necessary for the operator to move a master control switch to the final point. This closes contactors which put the torque motor on its high speed winding and thus brings the car mule out of the pit at a speed of 150 ft. per min. As the car mule approaches the coal car which has rolled over the hump, a limit switch operates and energizes intermediate circuits which puts the torque motor on its low-speed winding, so that the mule engages the coal car at a speed of 50 ft. per min. This operation also places the main motor on the line with all its starting resistance inserted. After the car has been picked up, another limit switch operates to energize a contactor which accelerates the main motor. This process continues in six steps until the main motor reaches its maximum speed of about 300 ft. per min. As the car approaches the car dumper cradle, the car is slowed down to 150 ft. per min. by inserting automatically all of the main motor resistance, and the torque motor is put on its high-speed winding. If the cradle is properly seated, the car and mule will proceed to the final mule limit; at this point the motors stop automatically and the brakes set. By reversal of the master switch, other motors change the position of the track gates through which the car mule leaves or enters the pit, and the car mule is lowered automatically.

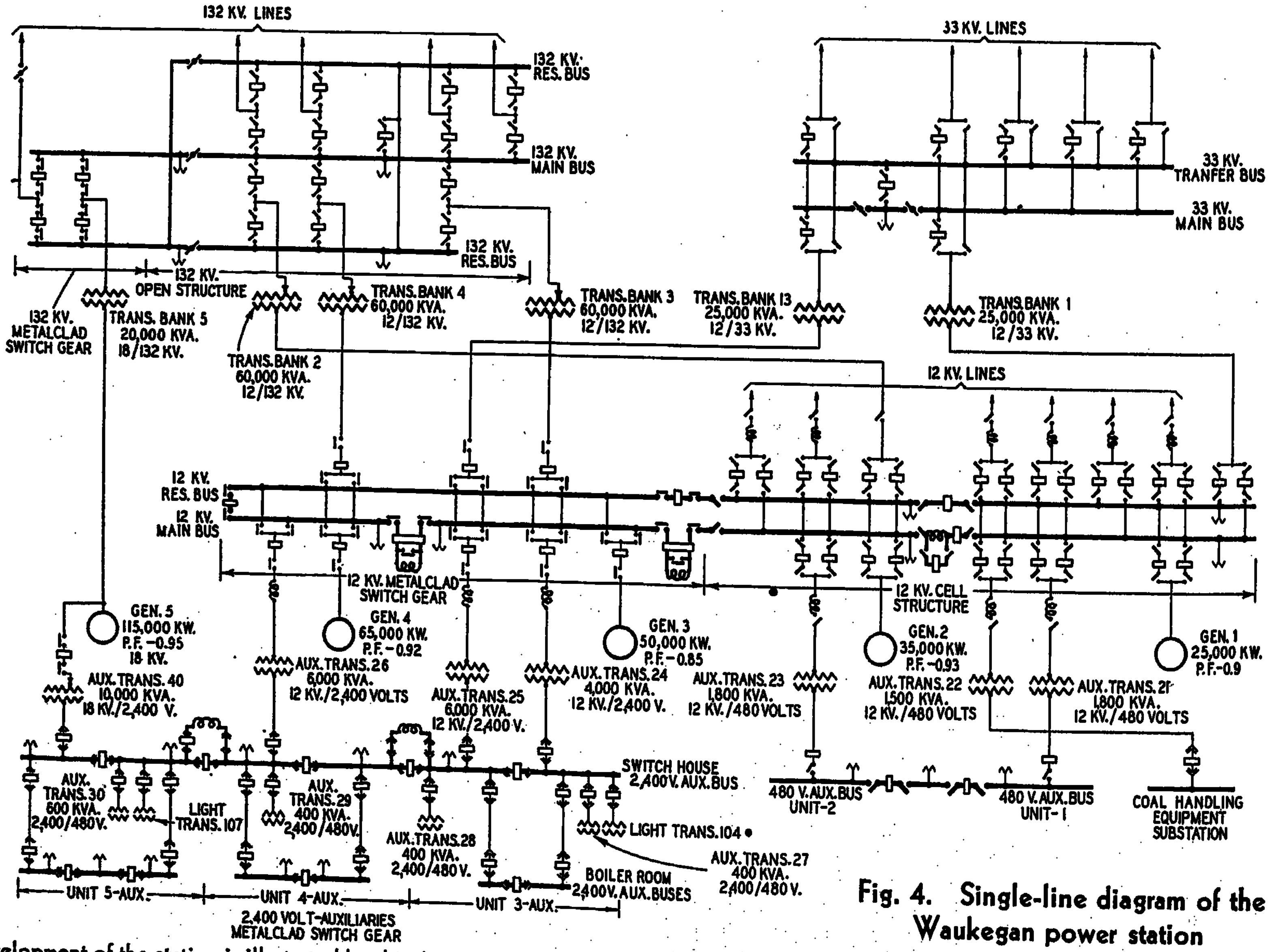
132 KV. LINES
132 KV. RES. BUS
132 KV. MAIN BUS
132 KV. RES. BUS
132 KV. OPEN STRUCTURE
132 KV. METALCLAD SWITCH GEAR
TRANS. BANK 5 20,000 KVA. 18/132 KV.
TRANS. BANK 2 60,000 KVA. 12/132 KV.
TRANS. BANK 4 60,000 KVA. 12/132 KV.
TRANS. BANK 3 60,000 KVA. 12/132 KV.
TRANS. BANK 13 25,000 KVA. 12/33 KV.
33 KV. LINES
33 KV. TRANFER BUS
33 KV. MAIN BUS
TRANS. BANK 1 25,000 KVA. 12/33 KV.
12 KV. LINES
12 KV. RES. BUS
12 KV. MAIN BUS
12 KV. METALCLAD SWITCH GEAR
12 KV. CELL STRUCTURE
GEN. 5 115,000 KW. P.F. -0.95 18 KV.
GEN. 4 65,000 KW. P.F. -0.92
GEN. 3 50,000 KW. P.F. -0.85
GEN. 2 35,000 KW. P.F. -0.93
GEN. 1 25,000 KW. P.F. -0.9
AUX. TRANS. 40 10,000 KVA. 18 KV./2,400 V.
AUX. TRANS. 26 6,000 KVA. 12 KV./2,400 VOLTS
AUX. TRANS. 25 6,000 KVA. 12 KV./2,400 V.
AUX. TRANS. 24 4,000 KVA. 12 KV./2,400 V.
AUX. TRANS. 23 1,800 KVA. 12 KV./480 VOLTS
AUX. TRANS. 22 1,500 KVA. 12 KV./480 VOLTS
AUX. TRANS. 21 1,800 KVA. 12 KV./480 VOLTS
AUX. TRANS. 30 600 KVA. 2,400/480V.
LIGHT TRANS. 107
AUX. TRANS. 29 400 KVA. 2,400/480V.
AUX. TRANS. 28 400 KVA. 2,400/480 V.
SWITCH HOUSE 2,400V. AUX. BUS
LIGHT TRANS. 104
AUX. TRANS. 27 400 KVA. 2,400/480 V.
BOILER ROOM 2,400V. AUX. BUSES
480 V. AUX. BUS UNIT-2
480 V. AUX. BUS UNIT-1
COAL HANDLING EQUIPMENT SUBSTATION
UNIT 5-AUX.
UNIT 4-AUX.
UNIT 3-AUX.
2,400 VOLT-AUXILIARIES METALCLAD SWITCH GEAR

**Fig. 4. Single-line diagram of the Waukegan power station**

Development of the station is illustrated by this diagram, the generating units having been installed in the order 1 to 5. The later auxiliary bus is 2,400 volts with metal-clad switchgear instead of the earlier 480-volt open type bus with connections extending from the oil switches up to the disconnecting switches and then to the overhead bus. Instead of the 12-kv. cell type structure used with the earlier units, later units have 12-kv. metal-clad switchgear with one circuit breaker and two selector switches to connect with both main and reserve buses. In the most recent installation, generator 5, the generator and its transformers are operated as a unit, the switchgear being the 132-kv. metal-clad type

# A 115,000-Kw. Turbo-Alternator

The tendency of large steam turbine design toward single-shaft units has greatly increased the size of generators operating at 1,800 r.p.m. Consequently, the designer has had to solve a number of problems, mechanical and electrical, because of the great axial length of these machines and the large weights involved, particularly in the rotor. A new scheme of rotor ventilation and other features of such an alternator are described in this article.

By
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FELLOW A.I.E.E.

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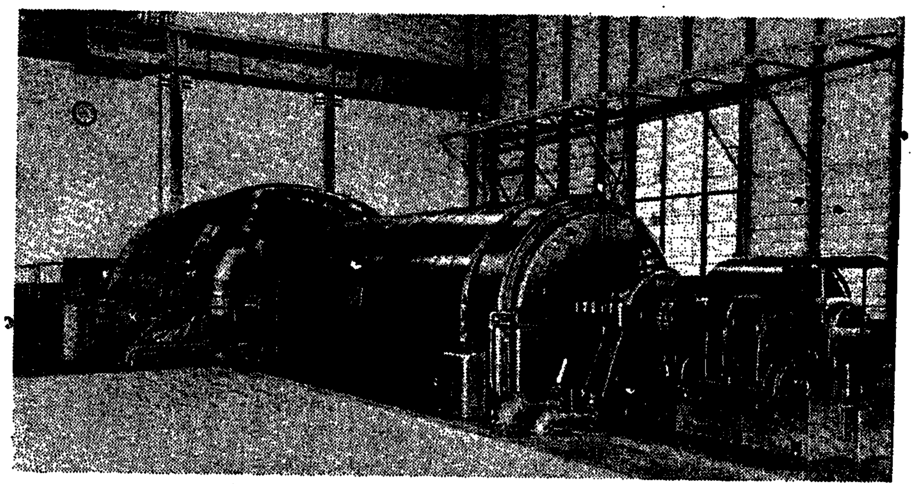

Fig. 1. The 115,000-kw. single-shaft unit installed in the Waukegan station

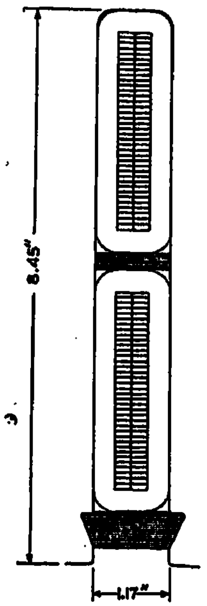

Fig. 2. Stator slot section

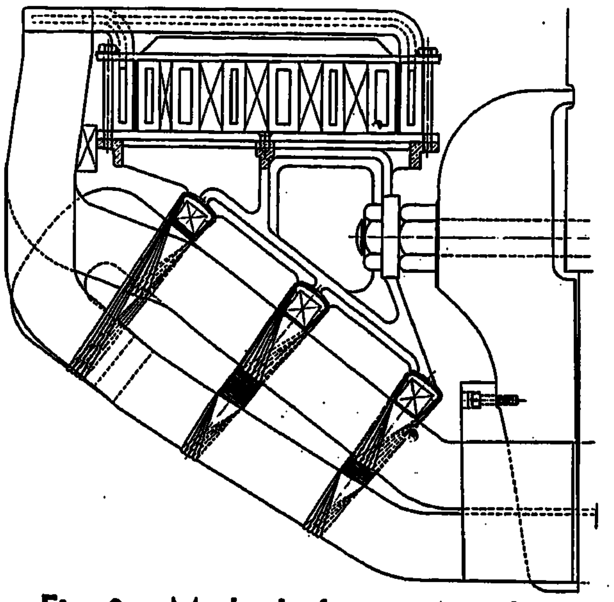

Fig. 3. Method of supporting the projecting ends of the stator coils

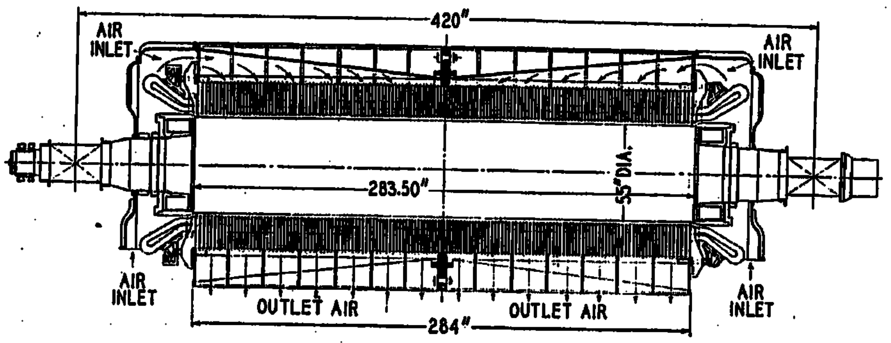

Fig. 4. Sectional view of the generator

IN SEPTEMBER 1931 a 115,000-kw., 0.95-power factor, 121,000-kva., 1,800-r.p.m. generator was put into operation in the Waukegan station of the Public Service Company of Northern Illinois. The station is described in two preceding articles, "Development of the Waukegan Station" and "Waukegan Features New Electrical Designs."

This generator is wound for 18,000 volts, 3,884 amperes, three-phase, 60 cycles. The voltage for this generator was decided after careful study, both from the operating point of view and from considerations of generator design. The whole output of the machine, with the exception of a small part used for the operation of station auxiliaries, is stepped up and all switching done on the high voltage side of the transformers; hence the voltage of this unit did not have to correspond with that of the older units in the station, and it was possible to wind the generator for 18,000 volts in order to obtain the best type of stator winding. The stator winding is placed in 84 open slots, 21 per pole, and connected in two parallel circuits. Two conductors per slot give the simplest form of winding and eliminate practically all danger of insulation breakdown between turns. The coils are made in halves, each conductor being built up of asbestos-covered, varnish-treated strands transposed to eliminate stray currents. At each end of the stator the half coils are connected together with solid clips to form one-turn coils. Since the winding is in two parallel circuits, each conductor carries one-half of the total current output.

The coils are insulated with mica tape, with asphaltum base binder. The insulation is molded in place in such a manner as to secure a dense insulation free from air inclusions. A layer of asbestos tape treated with varnish is placed on the outside of the coils to form a corona sheath. The whole winding was subjected to the standard A.I.E.E. test of 37,000 volts for one minute and there was very little evidence of corona at this voltage. The stator slot and arrangement of conductors are shown in Fig. 2. The projecting ends of the coils, Fig. 3, are supported by lashing to insulated non-magnetic brackets which form ring supports and at the same time avoid closed circuits for stray currents induced by leakage fluxes. In Fig. 4 is shown a sectional view of the generator.

The terminals of the winding are brought out at each side of the end housing so as not to interfere

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Based upon "115,000-Kw. Turbo-Alternator" (No. 32-58) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14-16, 1932.

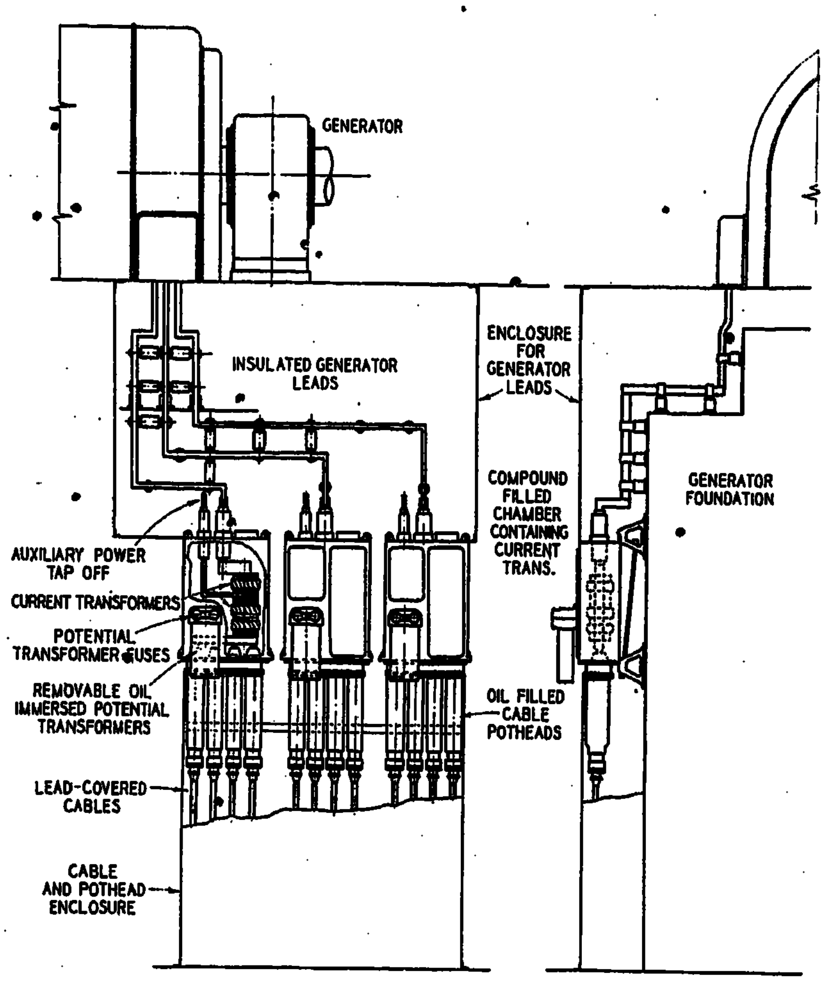
GENERATOR
INSULATED GENERATOR LEADS
ENCLOSURE FOR GENERATOR LEADS
COMPOUND FILLED CHAMBER CONTAINING CURRENT TRANS.
GENERATOR FOUNDATION
AUXILIARY POWER TAP OFF
CURRENT TRANSFORMERS
POTENTIAL TRANSFORMER FUSES
REMOVABLE OIL IMMERSED POTENTIAL TRANSFORMERS
OIL FILLED CABLE POTHEADS
LEAD-COVERED CABLES
CABLE AND POTHEAD ENCLOSURE

Fig. 5. (Left) Terminal boxes for stator leads

with the air ducts, and also to render them accessible above the floor line of the unit. Line terminals are brought out on one side and neutrals on the other.

The arrangement of the special compound-filled terminal boxes on the line side of the generator is shown in Fig. 5. These boxes are mounted on the foundation wall directly below the outlet on the generator. Each of the leads is provided with a terminal box in which current transformers for differential protection are mounted. A tap for auxiliary power supply is taken off directly from the main leads as indicated, and a current transformer in the auxiliary tap is provided in the terminal box, together with potential transformers for the machine. The whole arrangement is compact and affords a high degree of insulation. The boxes are filled with soft compound and the potential transformers are oil insulated. The cable potheads on the terminal boxes are oil filled, and lead-covered cables are carried down the side wall of the foundation and protected by a casing extending to the basement floor. This casing is made of aluminum plates bolted together so as to be readily removable.

The stator frame is of welded construction and made in two sections for convenience in handling, the halves being bolted together in a plane normal to the shaft at the center of the machine. An end view of the stator core and yoke with the stator laminations in place is shown in Fig. 6, while Fig. 7 shows the completed winding. The axial length of the laminated core is 281 in. (714 cm.) between end heads. The punchings are clamped between heavy finger plates of non-magnetic cast steel. In stacking the core, the laminations were pressed down by means of hydraulic jacks, as the work progressed. The core punchings are of silicon steel having a loss not to exceed 0.75 watt per lb. at a density of 10,000 c.g.s. lines per sq. cm., 60 cycles. The stator end enclosures are of non-magnetic cast iron. The stator with core and windings complete weighs 350,800 lb. net (159,000 kg.) and was shipped on a special car designed for 400,000 lb. (181,000 kg.) load.

## ROTOR CONSTRUCTION

The construction of the rotor for such a large high speed machine required a great deal of study as the weight of the finished rotor is 228,650 lb. (103,600 kg.). The weight of the rough turned forging was 240,000 lb. (109,000 kg.) and, before rough turning, 264,000 lb. (119,500 kg.). The forging was made from an ingot 108 in. (274 cm.) diameter, weighing approximately 480,000 lb. (218,000 kg.). The finished diameter of the rotor body is 55 in. (139.6 cm.) and the peripheral speed 26,000 ft. per min. (132 m. per sec.). There was considerable discussion with the steel makers as to the possibility of securing a sound forging of such large size and weight in a single piece. Several alternatives were considered, and it was finally decided to make the forging in one piece, but to arrange the design so that if difficulties were encountered the stub shafts could be cut off and stubs bolted to the body, thus making a three-piece construction. Fortunately this was not necessary, as the steel maker produced a single-piece forging which after careful physical tests and inspection by boring proved satisfactory in every respect.

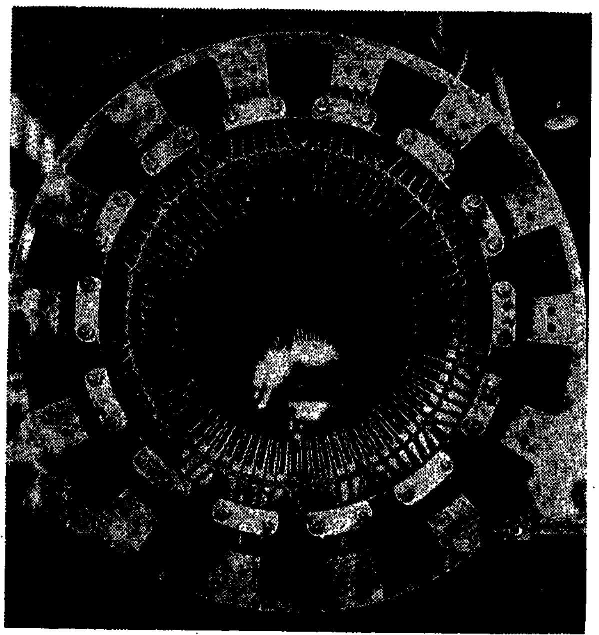

Fig. 6. (Right) Stator with laminations in place

The material in the rotor forging is open-hearth carbon steel, with a small percentage of vanadium thoroughly annealed. The body is approximately 24 ft. (732 cm.) long and the distance between bearing centers 420 in. (1,070 cm.). The rotor body after slotting, also one of the coil retaining rings, is shown in Fig. 8. The rotor is bored throughout its length with an 8-in. (20.3-cm.) hole, the surface of which is polished. The stub shafts are given a smooth finish, the same as on the bearing journals, to remove all tool marks and avoid localized stresses that might start cracks during long continued service. For the same reason all fillets on the rotor and end rings are carefully polished. The rotor end rings are of high tensile strength, non-magnetic, alloy steel in order to reduce stray loss.

In general, the rotor construction does not differ materially from that used for similar large rotors. All insulation is of mica and asbestos. On account of the large diameter of the stub shafts it was not advisable to mount the collector rings between the outboard bearing and the generator, as the rings would have to be of such large diameter that the rubbing speed at the brushes would be too high. The rings were therefore mounted outside the bearings, and leads brought through the shaft.

A new method of ventilation was used on this rotor because on account of its great axial length, the methods heretofore used would not be effective in ventilating the central part. The usual method of rotor ventilation has been to provide longitudinal channels under the coils, into which air can be drawn from each end of the rotor. Holes drilled down through the teeth connect with these channels and when the machine is in operation, air is drawn in from each end through the channels under the rotor coils and thrown out of the holes by centrifugal action. This method works well for rotors of medium length, but for very long machines it is difficult to secure enough inlet duct area under the coils to supply adequate ventilation; and what ventilation is obtained is not uniform along the length of the rotor body.

In the present case, instead of using the centrifugal effect and feeding air in at the bottom of the slots from each end, a method was devised for taking up air out of the air-gap at the circumference of the rotor and utilizing the impact head to force air down through the ventilating holes, returning it to the air-gap. Air from separate ventilating fans is supplied under pressure to the air chambers at each end of the stator and from there passes into 14 inlets (Figs. 3 and 4) spaced equally around the back of the stator punchings From these chambers it blows inward in a radial direction against the rotor, makes a U-turn and passes out radially through the yoke. Thus, air is blown in against the rotor at 14 points and this air is comparatively cool, as it has traveled only a short distance from the inlet. A small portion of the air is by-passed back of the coils in order to cool the part of the stator core behind the teeth, but the greater part blows in against the rotor. There is thus a strong circulation of air through the air-gap at all points throughout the length of the rotor.

The scrubbing action of the surface and the ventilation at the ends of the rotor removes a large part of the heat, but it is also necessary to provide additional ventilation as stated above. The method used in this case is shown in Fig. 9. Radial inlet holes are drilled to within a short distance of the roots of the teeth and outlet holes are drilled at an angle as shown, so as to connect with the former at the bottom. Plugs cut away on the under side are screwed into the tops of the inlet holes as indicated and a short channel is cut in the tooth lip as shown to connect with the slot in the under side of the plug. The plugs are of course locked in position so as to prevent any possibility of turning. When the rotor is rotating, at a peripheral speed in this case of 26,000 ft. per min. (132 m. per sec.), the impact head is sufficient to force air through inlet and outlet holes. Numerous tests made on models showed that the air velocity through the ventilating holes is at least 6,000 to 8,000 ft. per min. (30.5 to 40.7 m. per sec.). Also tests made with an experimental rotor, with and without these ventilating holes but otherwise under exactly similar conditions, showed a decided gain in cooling effect with the ventilating holes. The ventilation does not depend on any centrifugal action, as the centrifugal effects on the air in the inlet and outlet holes are balanced. With this arrangement, as the length of the rotor is increased, the number of ventilating units and the air carrying capacity are also increased in proportion, and a long rotor can be ventilated as effectively as a short one. It might be thought that this method of rotor ventilation would be noisy, but such has not proved to be the case as the rotor makes no more

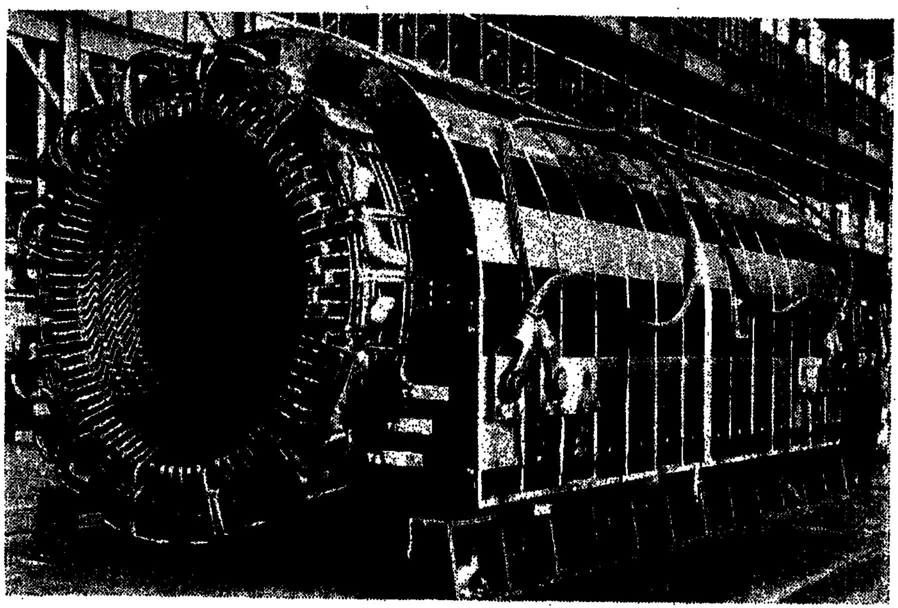

**Fig. 7. Stator with completed winding**

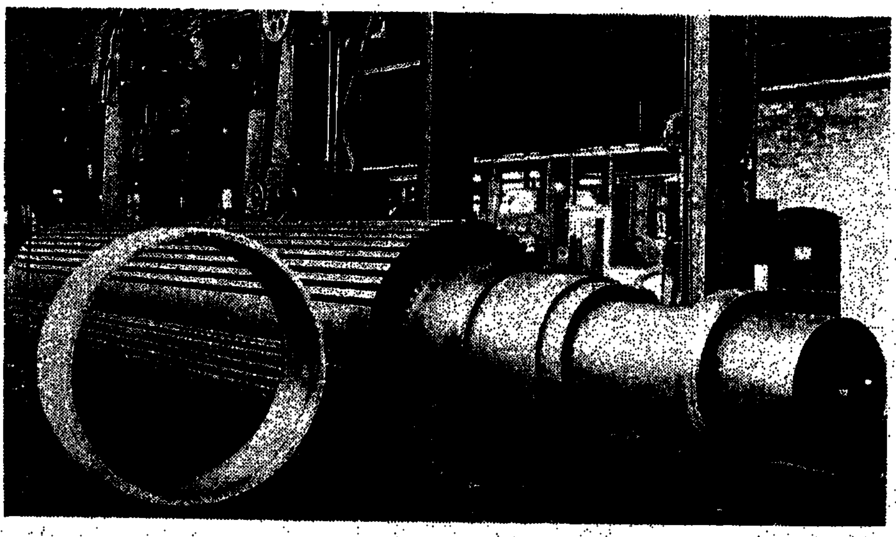

**Fig. 8. Rotor core and shaft after slotting, also one of the coil retaining rings (left)**

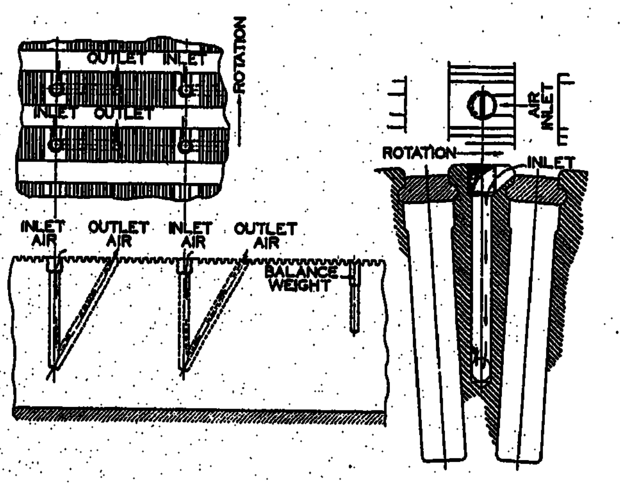

**Fig. 9. Method of securing rotor ventilation (right)**

noise than one provided with the usual centrifugal ventilation.

### AIR SUPPLY

Air is supplied to the generator by four separate motor driven blowers mounted within the foundation space, directly beneath the generator and operating on a closed system. Two of the blowers as installed are shown in Fig. 10, the other two being similarly located on the opposite side of the foundation.

Separate fans were used for several reasons. With a rotor of such large weight and length of body, it was necessary to keep the stub shafts as short as possible and the use of self-contained fans with their air inlets adds considerably to the length of the shaft. Moreover, the large shaft restricts the air inlets to such an extent that self-contained fans could not deliver the amount of air required without excessive inlet velocities and consequent loss in efficiency. Separate fans are more efficient and permit better mechanical design of the rotor, besides being more quiet in operation. Each fan can deliver 50,000 cu. ft. (1,420 cu. m.) of air per min. against 9-in. (22.8-cm.) static pressure. The fans operate at 1,160 r.p.m. and each requires a maximum of 104 hp. To allow ample margin, 150-hp. line-start, squirrel-cage motors are provided. The fans are single inlet type with runners mounted directly on a shaft extension of the motor. All four fan inlets open directly into the chamber under the coolers into which the air is discharged. With the generator delivering 70,000 to 80,000 kw. it is found that two fans furnish sufficient air, and four are operated only under full load conditions. Outlet dampers are provided on each fan so that it can be cut off when not in use. Fig. 11 shows the general arrangement of the blowers in relation to the generator and air coolers.

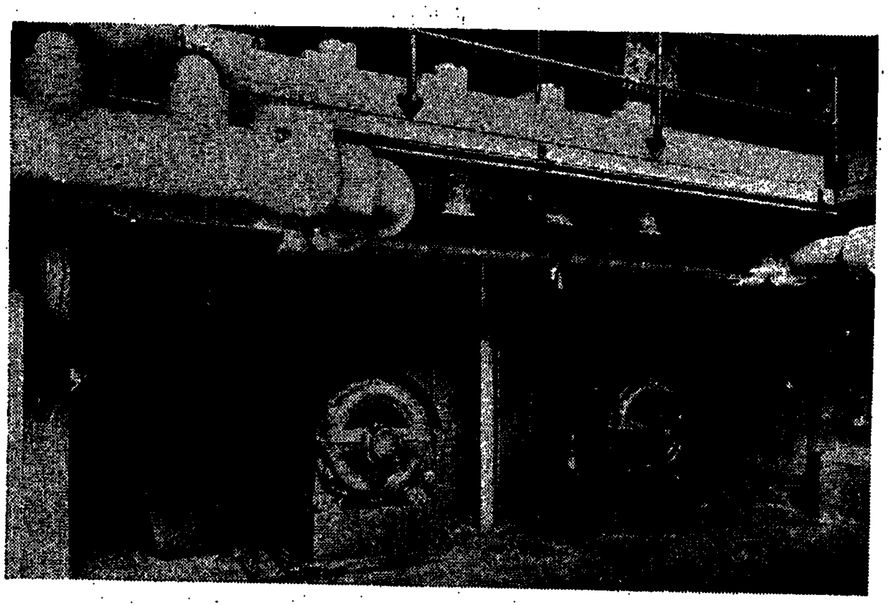

Fig. 10. Two of the four motor driven blowers

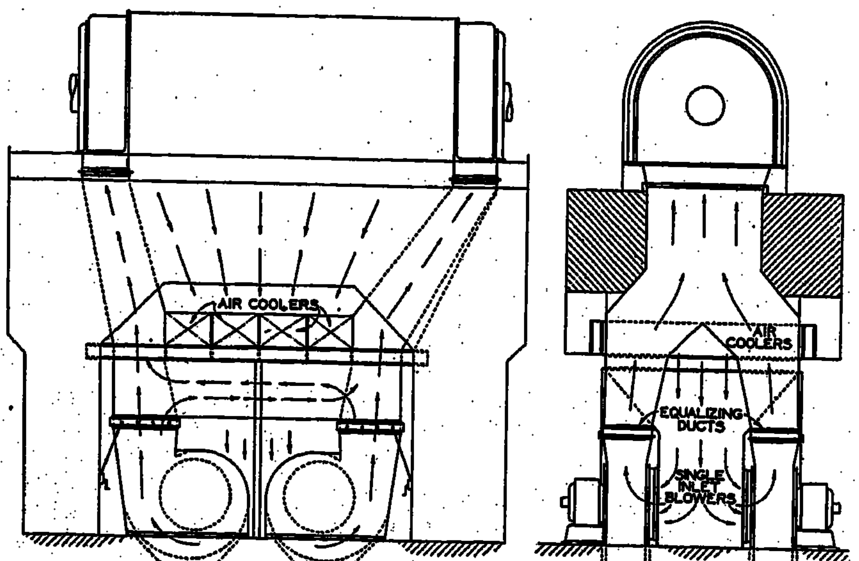

Fig. 11. General arrangement of blowers

For cooling the air, condensate is circulated through a fin type radiator cooler mounted directly under the generator. The cooler is designed to handle 200,000 cu. ft. (5,670 cu. m.) of air per min. with a pressure drop not exceeding $1^1/_2$ in. (3.81 cm.) water. With cooling water temperature not exceeding 80 deg. fahr. (26.6 deg. cent.), it will absorb 6,985,000 B.t.u. per hour and deliver air to the generator inlets at a temperature not exceeding 104 deg. fahr. (40 deg. cent.).

### EXCITATION AND ALTERNATOR CHARACTERISTICS

The rotor is wound for 250-volt excitation and current is supplied by a 350-kw. shunt wound exciter coupled to the turbo-alternator. The main exciter is a two-bearing machine with bearings lubricated from the oil circulating system of the main unit. A pilot exciter of 7.5-kw. output is overhung on the main exciter. This 250-volt machine provides excitation for the fields of the main exciter.

As shown by shop tests, the excitation required to secure rated terminal voltage at no load is approximately 400 amperes, and that required to secure full load current on short circuit is approximately 600 amperes. Regular operation on the station load indicates that the temperature rise of the generator at full load is well within the guarantees of a 60-deg. cent. rise by detector on the stator, and an 85-deg. cent. rise by resistance on the rotor. The estimated efficiency of the generator at rated load, including power required to drive the separate fans, is 98.1 per cent.

# An "Exponential" Slide Rule

AN "EXPONENTIAL" slide rule has been developed to facilitate problems involving the logarithms or antilogarithms of numbers. It differs from the ordinary slide rule of logarithms in two fundamental respects: (1) natural logarithms (to the base $e = 2.71828$) are given, and (2) both the characteristic and mantissa are determined directly in one reading. Logarithms of numbers from 0.00001 to 100,000, and the corresponding antilogarithms are given. As the addition of the characteristic normally would reduce the accuracy of the rule, the scale of logarithms has been split up into five 10-in. sections, thus giving an accuracy comparable with that of the ordinary rule. This exponential slide rule was developed by L. B. Sklar (A '30) 816 North 6th Street, Philadelphia, Pa.

Mr. Sklar states that for determining the logarithms of numbers less than unity, he has discovered a method which may be used both with his new rule and with the ordinary polyphase slide rule. This method involves the use of the *CI* scale in conjunction with the *L* scale, instead of the customary use of the *D* scale with the *L* scale. In dealing with logarithms of numbers less than unity, this method saves time and simplifies the steps involved with a resulting decrease in the possibility of error.

To find, for example, the value of $0.0003^{1.47}$ place the runner of the ordinary slide rule at 3 on the *CI* scale and read the mantissa −0.523 on the *L* scale. The characteristic for numbers less than unity always is equal to the number of zeros, and therefore in this case is −3; the logarithm thus is −3.523. Multiplying this by 1.47 gives −5.18, and the antilogarithm of this number must next be found. Placing the slider at 18 on the *L* scale gives 662 on the *CI* scale. The characteristic −5 indicates that there are five zeros following the decimal point, and the answer is therefore 0.00000662.

It may be seen that if this problem had been solved by the use of the *D* scale, as is customary, rather than the *CI* scale, it would have been necessary to add the step of making the usual subtraction before the correct logarithm is given. A similar subtraction would have been necessary in finding the antilogarithm, and to avoid error pencil-and-paper operations would have been necessary in performing these subtractions. The use of the *CI* scale instead of the *D* scale automatically eliminates the necessity of any subtraction in finding the logarithms of numbers less than unity.

# Motors for 3,000-Volt Multiple Unit Cars

**A new multiple unit car motor incorporating many novel design features was developed for the electrification of the Lackawanna suburban service in New Jersey. So far, these motors have required but little maintenance, and have been remarkably free from flashovers, insulation failures, and mechanical troubles.**

By
**J. C. AYDELOTT**
MEMBER A.I.E.E.

General Electric
Co., Erie, Pa.

ABSENCE OF TROUBLE in commencing service and in maintaining it has characterized the entire suburban electrification program of the Delaware, Lackawanna and Western Railroad. This is especially significant in view of the fact that it is the first multiple unit suburban service in this country employing a d-c. trolley potential of 3,000 volts. A notable lack of motor trouble is one of the factors responsible for the small number of maintenance difficulties experienced.

There are now in service on the Lackawanna railroad, 564 of these motors, the last 141 of which were placed in service on January 25, 1931, when the extension of the electrification to Dover was completed. By June 1, 1932, 13,000,000 car-miles had been operated, with only two train delays, one of nineteen minutes and one of four minutes, chargeable to motor failure. In view of this splendid operating record, it might be interesting to review briefly some of the motor design features that have contributed toward operating reliability.

Characteristics of the motor are shown by the curves of Fig. 1. The motor has a continuous rating of 97 amperes at 1,500 volts, with field shunt at 50 per cent, and a temperature rise not exceeding 105 deg. cent. above ambient. It has a one-hour rating of 130 amperes with a corresponding temperature rise not exceeding 120 deg. cent. above ambient.

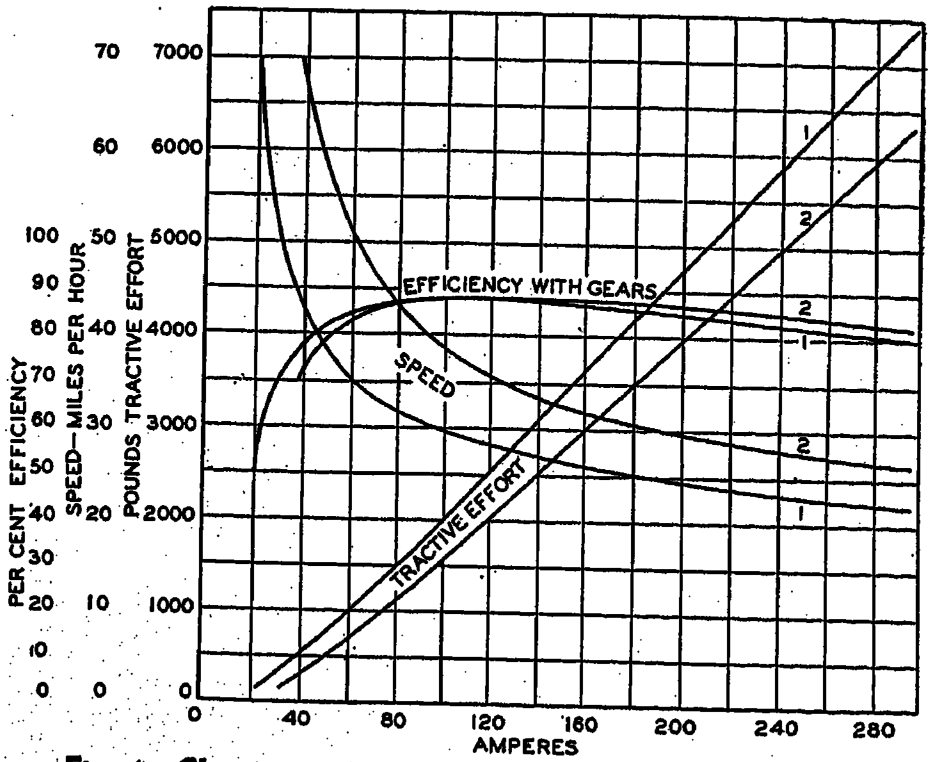

**Fig. 1. Characteristic curves for Lackawanna multiple unit car motors at two different field strengths**

1—Full field strength
2—Reduced field strength

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Based upon "Motors for 3,000-Volt D-C. Multiple Unit Cars" (No. 32-36) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25-29, 1932; subsequently brought up to date by the author.

## MOTOR FLASHOVERS MINIMIZED

So far, the motors have been remarkably free from flashovers, insulation failures, and mechanical troubles. Minimizing of motor flashing is an achievement embracing many features of design. Flashing may be caused by interruptions or disturbances in the voltage applied to the motors; also many things within the motor itself may contribute to flashing, some of these being poor commutator condition, commutator roughness, oil and dirt between commutator bars, flat spots, bouncing brushes, and low motor stability.

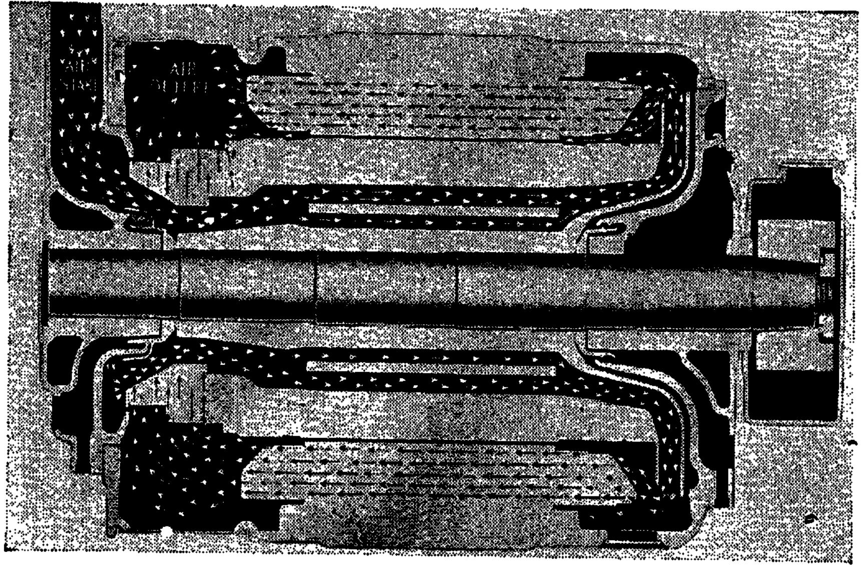

Fig. 2. Cross-section of motor for 3,000-volt d-c. multiple unit cars showing ventilation system

Successful operation of this motor demonstrates the feasibility of a relatively high commutator bar potential. With 281 commutator segments and 1,500 volts applied to the motor terminals, this amounts to 21.3 volts per bar, which is higher than previously used in any 3,000-volt railway motor. Successful operation under these conditions, however, depends upon commutating characteristics that will keep the commutator always in first class condition, and also upon the ability of the motor to withstand frequent wide and sudden variations of trolley voltage on full or weak field with a minimum of "spit" at the brushes.

Good commutation depends first upon keeping the reactance of the armature conductors at a minimum so that the energy involved in the reversal of current in a conductor is low. Besides this, the compensation, which depends upon the quantity of commutating pole flux, must have the required value at all loads. The design of this motor employs a one-turn armature winding. Careful attention was given to the number of slots and the proportions of the slots, air-gap and pole faces. Armature bars are clipped at the back thus permitting a "breaking up of the slots" which has long been a feature of good railway motor design. Nonmagnetic binding wire is used to reduce slot reactance.

It is well known that good commutation usually can be obtained at some one motor load depending upon the adjustment of the commutating field strength; common practise has been to adjust compensation for minimum sparking at some load near the one-hour rating. If the commutating poles were somewhat saturated at this point, the motor would be over-compensated for all lighter loads. To avoid this condition the design of this motor includes ample commutating pole cross-section; as a result, commutation is good from the lightest load to four times the continuous rating. Light loads are mentioned particularly because no sacrifice of commutation at light loads has been made to obtain correct compensation at heavy loads.

To an unusual degree this motor has ability to withstand flashover from voltage interruption. This may be attributed largely to the use of highly responsive commutating poles. Extra turns are wound on the commutating coils; under steady-load conditions the extra magnetomotive force thus produced is consumed in non-magnetic shims at the back of the commutating pole pieces. Thus the commutating pole flux follows very quickly any change in the armature current and tends to maintain correct compensation even under extreme transient conditions. A strong exciting field winding adds to the stability of the motor. The use of an inductive shunt rather than field tapping to obtain weak fields gives any motor a greater ability to withstand flashover from interruption during reduced field operation. In the Lackawanna motor the inductance of the field shunt has been so proportioned that the ability of the motor to withstand flashover on reduced field is superior even to its performance on full field.

## VENTILATION SYSTEM KEEPS MOTORS CLEAN

Motor flashing that might be caused by dirt is avoided by the ventilating scheme developed for this motor. No external blowers are used, but with the system of ventilation adopted the motor operates at all times with its interior either at or slightly above atmospheric pressure. The motors are self-ventilated as shown in Fig. 2. Cooperation of the car builder permitted the ventilating air to be taken from settling chambers over the vestibules to which it is admitted through louvers at each corner of the car roof. A separate duct to each motor extends down through the side and along under the floor of the car to a point over the commutator end bearing where a flexible air connection made of cloth sewed over a coiled wire leads the air to the motor inlet in the commutator end framehead. The flow of air is maintained by a fan on the motor shaft. Air enters the motor under the commutator and passes first through the ducts in the armature; it is then returned by the fan through the field structure of the motor and exhausted at the commutator end. The air outlet opening is covered with an expanded metal screen and a hood, so that foreign material cannot fall or be thrown into the motor.

This method maintains pressure inside all the exposed surfaces of a self-ventilated motor, which means that track dirt, fine snow, or brakeshoe dust cannot enter. It should be noted also that before the ventilating air reaches the commutator chamber of the motor it is filtered, so to speak, through both the armature and the field coils. Furthermore, any carbon dust originating in the commutator chamber is carried directly to the exhaust openings and does not enter any other parts of the motor. Routine inspections have shown these motors to be unusually clean. Surplus oil from the bearings is led through ducts to the outside of the motor and none finds its way inside.

## COMMUTATOR DESIGN

Smooth commutators depend not only upon good commutating characteristics but also upon good mechanical design and construction. The use of four brushholders and the low armature current resulting from the high voltage employed permit the commutator to be compact and strong. The commutator has a diameter of $16\frac{1}{4}$ in. and a brush surface $2\frac{3}{4}$ in. wide. With the cars operating at 70 miles per hr. at least once during every round trip, the motor speed reaches 1,800 r.p.m. At this speed the peripheral velocity at the commutator surface is 7,620 ft. per min.

When the motors were first put into service some brush breakage occurred at high speeds. In a short time, however, the commutators became seasoned so that brush breakage was practically eliminated. The brushholders also play their part in maintaining good commutating conditions. Pressure fingers are of the steel clock-spring type, having low inertia and maintaining their tension permanently; they are centrally located by recessed adjusting sleeves clamped by the first turn of the springs. A non-resilient brush is used to maintain contact with the commutator at high speed. As no abrasive action is necessary to keep the commutator smooth, the brush may be comparatively soft, of low friction coefficient, and may operate with a high contact voltage drop.

Insulation of the motor throughout is in accordance with recognized standards for 3,000-volt railway motors. While the absence of insulation failures in the motors thus far covers a comparatively short period, experience has shown that the same kind of insulation in other 3,000-volt motors lasts indefinitely, failures seldom occurring from any other cause than mechanical damage.

## RATINGS

Ratings of the motors when ventilated as in service are as follows:

| | Volts | Field strength | Shaft hp. | Amperes | R.p.m. | Temperature rise deg. cent. |
|---|---|---|---|---|---|---|
| Continuous | 1,500 | 50% | 181 | 97.0 | 1,055 | 105 |
| One hour | 1,500 | 50% | 255 | 137.0 | 913 | 120 |

Although during the time that it is connected the inductive shunt carries 50 per cent of the current passing through the motor, it has a continuous rating of only 34 amperes. The field shunt is designed with a temperature rise characteristic that, at the r.m.s. current obtained in continuous suburban service, will give a temperature rise approximately equal to the corresponding temperature rise of the traction motor exciting fields. Cold equipments coupled in train with hot equipments will share the load equally.

On short runs the r.m.s. current of the shunt slightly exceeds its rating, reaching a peak value on runs of approximately 3,000 ft., where the calculated r.m.s. value is approximately 37 amperes. However, under these conditions the r.m.s. current of the motor exceeds its continuous rating for 105 deg. cent. rise by resistance. Not only was the present electrification of the Lackawanna considered in studying shunt capacity, but also the possibility of extensions into more mountainous territory involving long uphill runs. These studies indicate that these runs do not require a shunt rating of more than one-third the continuous motor rating for 50 per cent field strength operation; this reduction in shunt rating permits a saving in weight.

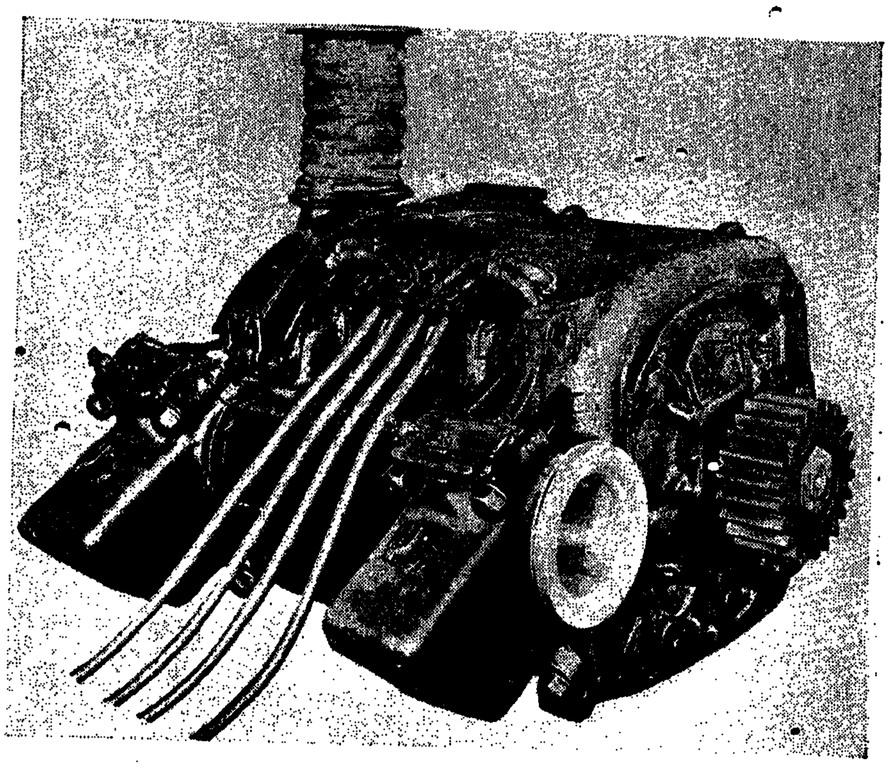

**Fig. 3. Complete motor showing pinion and axle bearings. Note "pants-leg" air duct connector at the upper left**

A view of the complete motor is shown in Fig. 3. Four motors are used on a motor car weighing 81.5 tons loaded; this, together with a trail car weighing 56.5 tons, forms a two-car unit of 138 tons. The motor weighs complete with gear, gear case, and axle lining, 6,850 lb., giving a weight per horsepower of 26.9 lb. The four motors give a capacity for the two-car units of 7.4 hp. per ton. Trains for use in short run commuter service may be made of 2, 4, 6, 8, 10, or 12 cars, half of which in each case are motor cars. A typical six-car train has a free running speed of 67 miles per hr. on level track (Davis friction) and a maximum permissible speed of 70 miles per hr.

Design of the motors permits the use of as high a train accelerating rate as desired, limited only by the weight on drivers and the slipping point of the wheels. Normally, an automatic acceleration of 1.5 miles per hr. per sec. is maintained, corresponding to an adhesion of 12.8 per cent. Acceleration tests have shown an equipment to be capable of reaching 30 miles per hr. in 20 sec. and 47 miles per hr. in 60 sec.

In frequent stop service a four-motor equipment is well loaded by a motor car and trailer unit, the motor temperature approaching the permissible limit for class B insulation of asbestos and mica tape. Experience has shown, however, that for railway motors, class B insulation tightly applied, molded, and hot-drawn will have a longer life if the motors are run hot enough to keep them free from moisture. In long run service the motors will have sufficient excess capacity to permit the handling of additional trailers.

### MECHANICAL DESIGN

Conservative interpretation of experience characterizes every feature of the mechanical design contributing to low maintenance. Stresses in all working parts are low. Both armature and axle bearings are of the sleeve type and embody the constant oil level feature permitting oiling periods to be extended to several times the usual period. There is a layer of babbitt on the wearing surfaces of the bore and flanges of all the bearings. The almost complete absence of hot bearings during the initial stages of the electrification was due not only to design, but to the fact that all of the linings were line reamed after assembly in their respective final positions, and due also to the careful packing of the bearings, oiling, and breaking in.

Operation of the gearing on the motors is quiet, promising long life. Gears are of special heat-treated steel, General Electric Company grade F, 2¼ pitch, with long and short addendum tooth form. To insure correct profile, the gear teeth were ground after treatment. Possibility of the gears giving off ringing notes has been overcome by a non-resonant feature obtained by snapping rings of small cross-section into annular grooves machined in the under side of the rim. These rings have a different period of vibration from that of the gear section, thereby counteracting or destroying the vibrations in the gear. The manner in which the rings are assembled provides an annular pocket for the retention of gear grease; this also has a decided damping effect. After assembly, the rings are welded at the joint to prevent any possibility of their coming loose. Gear cases are of malleable iron with three point support.

During eighteen months of operation the maintenance expense of these motors has been extremely low. The time when commutators will have to be turned down is still in the remote future. Very few motors have been removed from the cars for any purpose. There is every reason to expect continued low maintenance for this first multiple unit suburban electrification employing a d-c. trolley potential of 3,000 volts.

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# Refrigeration Improves the Health of Millions

By
WILLIAM H. ADAMS
Detroit, Mich.

ENGINEERING with its benefits enters our homes daily in many ways. Manufacture of artificial ice and mechanical cooling of space have become commonplaces and constitute a major achievement of engineering and science.

But a short generation ago, people lived principally on salt meats, salted and dried fish, dried grains, and dried fruits, and on foods conserved by the early canning and preserving arts, except for a few weeks or months when fresh fruits and vegetables were available from nearby truck farms. The refrigerator freight car and the modern cold-storage warehouse have changed the eating habits of a large part of our people and have brought to the tables of millions of industrial workers articles of food that but recently were the luxuries of the rich.

Early efforts to cool space and goods by the use of natural ice were but partially successful; low temperatures were difficult to obtain and harder to hold uniform. The modern cold-storage warehouse, with temperatures held at any desired level and with but fractional degrees of change, will keep food products in fresh condition for almost an indefinite period.

The consumer has benefited by the lengthened list of foods available, and the health of our people has been improved by this diversity of diet and by the inclusion of vitamin-bearing fruits and vegetables. Instead of the occasional glutted market and then scarcity, the produce of farm, dairy, orchard, and garden now reaches the consumer in orderly and regulated quantities and with a minimum of loss. Lands remote from population centers but well adapted to the production of perishable crops thus may be used with confidence that refrigerated transportation and cold storage at points of consumption or in transit will result in distribution over an adequate time and with the widest possible market.

Our theaters now are cooled and de-humidified mechanically; trains with interior temperatures held at the comfort line ply between our cities and across the desert; office buildings are becoming available with air-conditioning as an added aid to efficiency and comfort. In the most recent field of domestic mechanical refrigeration, more than three million units were in use at the end of 1930, and it is estimated that an additional million were in service by the end of 1931. Presently, at the touch of a switch, our homes will be cooled in summer as readily as they now are warmed in winter.

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**Editor's Note:** This is the eleventh article in the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?" Pursuant to the invitation of the Engineering Foundation, the editors will be happy to receive comments, criticisms, or discussions pertaining to this or other articles published in this series.

# Abstracts

## Of Papers to Be Presented at the Summer Convention

INTERPRETIVE abstracts of all technical papers to be presented at the A.I.E.E. summer convention, June 20–24, 1932, are included herewith, excepting only two papers. One of these is published in full on p. 390–1 of this issue; for the other, manuscript had not been received at the time this issue went to press. Members vitally interested and wishing to obtain pamphlet copies may do so by writing to the A.I.E.E. Order Dept., 33 W. 39th Street, New York, N. Y., stating title, author, and number of paper desired. In response to popular demand and within its space limitations ELECTRICAL ENGINEERING subsequently may publish certain of these papers, or technical articles based upon them.

### The Engineering Subjects in the Four-Year College Program of Electrical Engineering

By
A. H. Lovell[1]

THE PRACTISING engineer is vitally concerned with education because the young graduates are trained to meet the specifications of his profession, to join its ranks, and to work beside him in the years to come. He should give advice therefore as to the economic and professional content and interrelation of the programs.

The Society for the Promotion of Engineering Education report of the study of engineering education from 1923 to 1929 gave valuable recommendations as to the preparatory and secondary subjects in the curricula. In view of the developments of the past few years and of immediate future demands, it is time to study the technological portion of the curriculum in electrical engineering. Studies show what some 33 representative schools provide in required and elective electrical divisions and the semester hours required in cognate engineering subjects. Consideration, study, and suggestions are requested from the members of the Institute who are engaged in active practise. (A.I.E.E. paper No. 32-74)

### Educational Aspects of Engineering and Management

By
R. E. Doherty[2]

SURVEYS made by sending questionnaires to organized groups of engineers have established some important facts regarding functional distribution and financial reward. These facts have been interpreted differently, but in order to use them as the basis of any formulation of educational policy, they should be rationalized in terms of their historical setting. Such has been the object of this study. The three predominant facts from these surveys are:

1. More engineering graduates have ultimately gone into primarily administrative positions than have remained in pure technical engineering activity.
2. The former have received greater financial reward than the latter.
3. Excepting a few recent graduates, the former have learned practically all they have known regarding administration after they left college.

The present study indicates that it would be unwise to adopt either the policy of training college students primarily for management or allowing the technical engineering course itself to be sufficient. Both phases of training are necessary and an attempt should be made to emphasize the phase best suited for each individual.

Definite proposals are outlined regarding the type of college training for the professional groups; and an appeal is made that industry recognize the powerful influence which its past salary policy toward technical engineering leadership, as it is unquestionably reflected in these surveys, will have in turning talented minds away from technical engineering. The appeal is not merely to give such engineering its due, but, in industry's own interest, to prevent the problem in the next generation of having a dried up technical engineering leadership. (A.I.E.E. paper No. 32-75)

### Chicago District*

By
L. L. Perry[7]
F. V. Smith[7]

THE LOAD characteristics, generating stations, and transmission lines of the Chicago territory and particularly the power supply of Chicago proper, are outlined in this paper.

The economics of the scheme of supply are discussed from the points of view of interchange energy agreements, comparative incremental fuel costs of generating stations, incremental losses of transmission lines, load schedules, remote metering and load dispatching, economics of 550-lb. to 650-lb. units, automatic frequency regulation, control of voltage, phase angle, and wattless voltamperes.

The reliability of the system is outlined with respect to the design of generators, switchgear, transmission lines and cables, relay protection, methods of operation, and reserve capacity. From the experience gained in the Chicago territory, conclusions are drawn as to the policies of economy and reliability which have been adopted in operating the system. (A.I.E.E. paper No. 32-76)

### Philadelphia Electric Company's System*

By
J. W. Anderson[4]
Herbert Estrada[4]

MAXIMUM system economy is attained when the sum of operating costs plus fixed charges on investment is a minimum. Considerations of reliability usually lead to increased capital investment for sturdier facilities and for spare equipment, and consequently add to the fixed charge burden. Fortunately, however, operating costs are to some extent inversely proportional to fixed charges, and analyses of system performance often will reveal operating savings which can result from judicious use of investment in spare facilities.

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[1] University of Michigan, Ann Arbor.
[2] Yale University, New Haven, Conn.

* Part of a symposium on "Combined Aspects of Reliability and Economy in the Operation of Large Electric Systems."
[3] American Telephone & Telegraph Company, New York, N. Y.
[4] Philadelphia Electric Company, Philadelphia, Pa.
[5] Detroit Edison Company, Detroit, Mich.
[6] Edison Electric Illuminating Company of Boston, Mass.
[7] Sargent & Lundy, Inc., Chicago, Ill.

Practises followed on the Philadelphia Electric Company system are discussed in this paper from the standpoint of production facilities in attaining highest system economy consistent with a high degree of service reliability. As the system comprises steam and electric stations of different efficiencies, a large hydroelectric plant, and a major high voltage interconnection, the problems of operating economy are both highly important and complex in character.

The reliability of production facilities of this system is indicated by an analysis of the factors affecting customers' service. In 1931 no interruptions to customer service were caused by the failure of production facilities. Further, the operating economies obtained have resulted in a steady reduction of fuel rate per kw-hr. (A.I.E.E. paper No. 32-73)

## The Detroit Edison Company's System*

By
A. P. Fugill[5]

WITH BUT few exceptions, the requirements for extreme reliability and the economical use of resources in any electric system are diametrically opposed. It is not particularly difficult to design and operate a system to give any practicable degree of reliability of customer service if no consideration need be given to the price the customer must pay. On the other hand, if the service standards were lowered sufficiently, a system could be designed and operated with an over-all economy exceeding present values. The real problem is to obtain the required reliability with the maximum operating economy and the minimum of investment.

Reliability of the service furnished by the Detroit Edison Company is assured: first, by the design and installation of facilities to reduce the probability of outage; and second, by a system layout and operating procedure based on segregation and sectionalization to minimize the effect of any outage. Operating economy is secured: first, by the fundamental design of each new installation for reasonably low production cost; and second, by so allocating the load between generating stations that the more economical machines carry a greater percentage of the total load in so far as the physical location of the load makes this possible. (A.I.E.E. paper No. 32-70)

## The Edison Electric Illuminating Company of Boston's System*

By
R. E. Dillon[6]

IN THE DEVELOPMENT and operation of a successfully managed public utility reliability and economy must be based on the particular conditions inherent to the locality which it serves. As a result, every company's problems must have individual study and no set and fast rules can be established for their solution. However, the policies, practises, and experiences of each are helpful in molding the development of others.

The final plan for the addition of a large block of capacity in generating or distributing facilities is the result of a compromise between those features that seek a minimum of investment outlay, to be obtained by simplicity, and those that urge complications designed to give a high degree of operating flexibility in behalf of reliability. Reliability, it should be pointed out, is not necessarily sacrificed in the plan for less total investment. On some occasions reliability may be assured with smaller total investment by the installation of more spare capacity using simplified equipment at less cost per kw.

On the system of the Edison Electric Illuminating Company of Boston, the occasions of total interruption of service to any large single customer or group of smaller customers due to loss of transmission facilities have been negligible. A decided improvement in operating economy has been secured by generating units, turbines, and boiler equipment. Furthermore, automatic substations together with modern equipment have improved efficiency and reduced labor.

These changes came about in the course of providing for the growth of load. They were attended also with increasing education on the part of the attendants toward efficiency and an increasing vigilance of all forces against losses. (A.I.E.E. paper No. 32-71)

## Oxid Coatings on Aluminum

By
J. D. Edwards[10]
Martin Tosterud[10]
H. K. Work[10]

INTEREST in oxid coatings on aluminum began with the discovery of the metal about 100 years ago, for the chemical attraction of aluminum for oxygen is one of the most important characteristics of the metal. At various times in the history of aluminum, attention, from the scientific standpoint or from the commercial point of view, has been focused on the oxid film. To the scientist, for example, the electrical characteristics of the oxid film have been of great theoretical interest and for many years have been the subject of experimental study and speculation. Important commercial uses of the film in various electrical devices have followed upon the scientific studies.

The remarkable characteristics of the oxid film are discussed in this paper, and a large number of practical uses which can be made of these characteristics are pointed out. A very important characteristic of the film is its impermeability with high protective properties. Also, extensive use of film-coated aluminum has been made in the electrolytic rectifier, and more recently in the electrolytic condenser.

The extensive use of oxid coatings having thicknesses comparable with those of a paint film is a relatively recent development. By a special process films of greater thickness may be formed which have a hardness partaking of the characteristics of corundum and capable of being made of high dielectric strength so that they can be used for purposes of electrical insulation. These thick oxid films also can be colored by absorption of dyes or mineral pigments.

Many commercial uses other than those of the electrical industry may be made of the various types of oxid film. (A.I.E.E. paper No. 32-78)

## Calculation of Inductance and Current Distribution in Low Voltage Connections to Electric Furnaces

By
C. C. Levy[8]

LOW VOLTAGE circuits supplying electric furnaces present special problems in the calculation of inductance and current distribution, in that the conductors employed vary in arrangement and cross-section, and are relatively short. The very large currents carried give rise to reactive drops of greater magnitude than is usually supposed, and a detailed study of the inductance of such circuits therefore is desirable.

Formulas and methods are presented in this paper for the determination of the inductance of relatively short bars with the particular arrangements found in furnace circuits. Fundamental theorems for deriving geometrical mean distances first are established, leading to the well-known formulas for self-inductance and mutual inductance of circular and rectangular sections. Practical applications of these formulas to the problem of calculating the approximate reactive drop in single phase and three phase furnace circuits are worked up in great detail. The same calculations may be used to determine the approximate operating power factor of the furnace. Unequal current distribution in multiple conductors, due to proximity and skin effects, is shown by numerical applications.

The methods presented while not precise are sufficiently accurate for practical purposes and enable the avoiding of unnecessary reactance. (A.I.E.E. paper No. 32-79)

# Electrical Equipment for Precipitation Service

By
H. Speight[8]
V. G. Rydberg[9]

APPLICATION of a strong electrostatic field accompanied by corona discharge to the cleaning of gases was first shown by Hohlfeld in 1824. In 1884 his observations were extended by Sir Oliver Lodge, who continued the work and made a practical installation at a lead smelter in Scotland. In 1905 and 1906 this work was extended by Doctor Cottrell; this extension led to the development of the electrical precipitation process for the separation of solids and liquids from gases. This process is now used in a variety of applications.

For best results, uni-directional current is used, with a negative discharge electrode and positive collecting electrode. The electrical equipment generally employed consists of a specially designed transformer, mechanical rectifier, motor-generator, rectifier motor, switchboard, and accessories. There are, however, many disadvantages to the mechanical rectifier, and a tube type of rectifier has been developed to furnish uni-directional current for meeting the unusual load conditions encountered. This has the following advantages: Less space is required, no surges due to rectification will result in the circuit, the wave form supplied will be regular, the voltage will remain constant, no radio interference will result from the rectifying equipment, polarity is automatically controlled, and operation is very quiet.

The control scheme developed for the tube type of rectifier is relatively simple and is self-protective. The rectifier tube is of rugged construction, and for such tubes an operating life of over 4,000 hr. has been secured. Experience with these installations to date has given the important result that a higher recovery per kw. input is obtained than is secured with mechanical rectification. (A.I.E.E. paper No. 32-77)

# New Applications of Non-Linear Circuits to Relay and Control Problems

By
C. G. Suits[11]

CONNECTIONS of reactors and capacitors in series and in parallel permit obtaining voltampere characteristics which are non-linear and which present interesting possibilities when applied to voltage sensitive and current sensitive relays. With the reactor and capacitor connected in series and properly adjusted, there is a value of increasing voltage for which the current suddenly changes to a high value, and another value of decreasing voltage for which the current suddenly decreases. These characteristics assist in obtaining a relay which is sensitive to small changes in voltage. Similarly, a current sensitive relay can be obtained by the parallel connection of reactor and capacitor.

Based on this principle a voltage relay has been developed which employs a solenoid and armature contactor mechanism energized in parallel with the capacitor of a series non-linear circuit. When used on a source of constant frequency this type of resonant relay may be adjusted to a minimum difference between "pick-up" and "release" of 1/4 per cent and, by change in resistance alone, may be adjusted to a maximum difference of 30 per cent referred to the pick-up value. The maximum power requirement is six watts at twelve voltamperes. The frequency error is of the order of 1 per cent in voltage for a 1 per cent change in frequency.

Using a modification of this same principle, a current sensitive relay has been developed also for which the difference between the pick-up and release values may be adjusted between limits of 3 per cent and 15 per cent. As in the case of the voltage relay, the percentage difference between these values and their magnitude are separately adjustable. The total power input at the resonant current of the current relay is of the order of six watts at 6.5 voltamperes. (A.I.E.E. paper No. 32-85)

# Insulation Coordination of Distribution Transformers

By
E. D. Treanor[12]
W. H. Cooney[12]

AS AN ALTERNATIVE to the use of distribution transformers of present levels of dielectric strength with lightning arresters connected either in the customary manner or having the primary lightning arrester ground interconnected with the grounded neutral of the transformer secondary main, a study of the coordination of insulation of distribution transformers has been carried out.

Test results on distribution transformers designed to meet these requirements of coordinated insulation show that by the use of shields for the high voltage winding and thyrite resistors for the low voltage winding, transformers can be made in which the internal insulation will be protected by flashover of the bushings. The level of insulation chosen and the amount of system protection desired by the use of lightning arresters will determine the economic value of such transformers.

Whatever considerations apply to the discharge of impulses into the secondary circuit must be taken into account, with the knowledge that such transformers have a maintained level of strength which will minimize these discharges. As distribution transformers coordinated at the level of line insulation would be prohibitively expensive, a compromise based on sound past practise seems to present a logical improvement. (A.I.E.E. paper No. 32-80)

# Characteristics of Surge Generators

By
P. L. Bellaschi[13]

THE REQUIREMENTS and limitations of surge generators for transformer testing can be summed up as follows:

When the capacity of the transformer is great, the voltage that can be obtained is in the first place largely determined by the capacity of the surge generator.

If a wave is desired without superimposed oscillations, it is necessary to insert resistance within the generator. The front of the surge then depends on the inductance of the generator and the capacity of the transformer. This is a matter inherent with all surge generator test circuits. Thus, in general, waves of very steep front cannot be obtained with large transformers.

Further, the inserted resistance also limits the voltage by an amount dependent on the proportion of this resistance to the load resistance.

For transformers of low inductance, the length of the wave obtained is determined largely by the capacity of the surge generator. This results in a requirement of large generator capacity if very long waves are to be produced.

If the lead between the transformer and generator is appreciably long, other oscillations will be set up which are highly damped but are appreciable at the generator end. These oscillations occur on the front of the wave only, and will be prominent when measurements are taken at the surge generator. (A.I.E.E. paper No. 32-87)

# The Coordination of Transformer Insulation With Line Insulation

By
V. M. Montsinger[12]
W. M. Dann[13]

PUBLISHED in full in this issue of ELECTRICAL ENGINEERING, p. 390–1. (A.I.E.E. paper No. 32-64)

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[10] Aluminum Company of America, New Kensington, Pa.
[11] General Electric Company, Schenectady, N. Y.
[12] General Electric Company, Pittsfield, Mass.
[13] Westinghouse Electric & Mfg. Company, Sharon, Pa.

## Characteristics of Load Ratio Control Circuits

By
L. F. Blume[12]

THE INFLUENCE of saturation phenomena in series reactors on the circuit performance of load ratio control equipment has been made the subject of the present study. It has been found that unless care is exercised in the design of these reactors, gross distortion may be introduced into the circuit, resulting in obtaining across the reactor voltage peaks which may endanger the insulation, and greatly increase the rupturing duty of the circuit breakers.

Formulas which have been developed show that the proportion of line voltage absorbed by a series reactor subject to magnetic saturation, can be expressed in terms of the reactive constants of which the circuit is composed, and that the voltage is independent of the current or voltage wave form. Curves based upon numerical solutions show that the peak voltage across the reactor may be limited to relatively small values by the following:

1. Designing the reactors for relatively low flux density.
2. Using an air-gap which is at least 1 per cent of the total length of the magnetic circuit.
3. Designing the reactor with a large magnetizing current, so as to avoid excessive voltages when overload currents are flowing.
4. Providing the transformer with a larger number of small percentage steps so that the reactor may be designed for a smaller fraction of circuit voltage. (A.I.E.E. paper No. 32-81.)

## Single-Phase Short-Circuit Torque of a Synchronous Machine

By
C. A. Nickle[11]
C. A. Pierce[14]
M. L. Henderson[11]

THE ANALYSIS of synchronous machines previously published by Doherty and Nickle is extended in this paper to include the calculation of torque due to single phase short circuits. The torque is expressed as the sum of odd and even harmonic series which are simply related to those previously derived for the armature current. The effect of amortisseur windings also is taken into account. As an illustration of the application of the equations, the short-circuit torque is calculated for a 100,000-kva. generator.

The mathematical analysis and general equations are presented under the following divisions:

1. Short-circuit armature current.
2. Short-circuit torque.
3. Decrement factors.
4. Single-phase and three-phase reactances. (A.I.E.E. paper No. 32-72)

## Transient Analysis of A-C. Machinery—II

By
Yu H. Ku[15]

AN EXTENSION to salient pole machines is made in this paper, based upon the author's "Transient Analysis of A-C. Machinery." All of the cases as calculated in "Three-Phase Short-Circuit, Synchronous Machines—V," by R. E. Doherty and C. A. Nickel, A.I.E.E. TRANS., v. 49, 1930, p. 700–14, are recalculated by an exact analysis. It is stated that this analysis checks quite closely the approximate analysis of Doherty and Nickle.

Results are given also for a fictitious machine having essentially the same constants as the slotted rotor machine studied in the author's earlier paper, but with salient pole features. Thus comparisons are made regarding transient phenomena of salient pole and slotted rotor machines of essentially the same character.

The effect of external resistance is calculated for different values and, using the machine of Doherty and Nickle, the effect of external reactance and capacitance is also predicted. In the case of capacitance, self-excitation or negative damping is found to exist for certain critical values. (Pamphlet copies not available.)

## Influence on Commutation of Brush Contact Drop

By
L. R. Ludwig[8]
R. M. Baker[8]

IN DESIGNING electrical commutating machinery, an attempt is made usually to produce during commutation a linear change of current with time. This, however, is rarely achieved, and the current density therefore usually is not constant across the brush surface, nor is the contact drop constant. The contact drop also will change with time in any small area on the brush surface, and therefore the static curve between voltage and current measured at the brush contact cannot be used.

In this article the theory and mechanical nature of a sliding contact, the dimensions of a contact, and transient brush drop are discussed. Evidence was found that the number of contact points varied from 10 to more than 50, and these data made possible a determination of the size of contact point necessary to account for the voltage drop observed. It was found that the successful brush has a very large number of contact points, and thus has points of small area which will heat and cool with sufficient rapidity so that high transient voltages are avoided. (A.I.E.E. paper No. 32-66)

## Wire Communication Aids to Air Transportation

By
H. H. Nance[8]

HISTORY of air transportation within the past few years indicates that continued growth may be expected, particularly as hazards to flying are mitigated and safety and dependability are recognized by the public. The government is continuing the extension of airways, weather reporting, and other services, and air transport companies are progressing in developing transport business. Fast and reliable communication service has proved the backbone of weather and position reporting, and has been a valuable aid in the handling of traffic.

Teletypewriter circuits used for land service have been found particularly suited to meeting the various requirements involving simultaneous communication with many stations at remote distances. Other wire communication services, such as long distance telephone and commercial telegraph, have aided also, particularly in reaching points not served by teletypewriter circuits. It is expected wire communication service will continue to be used extensively in connection with air transportation, and will be of considerable aid in its future development. (A.I.E.E. paper No. 32-82)

## Characteristics of Electromagnetic Radiation From Aircraft in Flight

By
J. C. Coe[16]
T. C. Rives[16]

DURING 75 flights made in the vicinity of Wright Field, Dayton, Ohio, during 1931, data have been collected to determine the intensity of electromagnetic radiation from aircraft in flight.

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[14] Worcester Polytechnic Institute, Worcester, Mass.

[15] National University of Chekiang, Hangchow, China.

[16] Signal Corps., War Dept., Wright Field, Dayton, Ohio.

The radiation from the airplane was recorded by a field-strength measuring set located in a frame building. Attenuation was found to be a function of altitude and frequency, while absorption is a function of frequency and the time of day. The occurrence of fading is shown to be determined by these factors.

Among the conclusions which may be drawn from these data are that for ground distances of 0.4 mile or less the field strength decreases with altitude; while at 1 mile there is comparatively little change in field strength with altitude; and for ground distances of 4 miles or more the field strength increases with altitude. There was no difference between the night tests and the daylight tests, provided that the same conditions obtained as to power, antenna, frequency, and altitude, except that the distances free from fading were much less by night than by day. The results of various tests in which fading was encountered at distances under 60 miles lead to the conclusion that the absorption undergone by the reflected or refracted ray is independent of the angle or distance traveled by that ray. (A.I.E.E. paper No. 32-83)

## Vertically Cut Sound Records

By
H. A. Frederick[17]
H. C. Harrison[17]

FUNDAMENTAL advances in recording and reproducing sound have been made recently through the use of vertical undulations on a disk. These vertically cut disk sound records possess important advantages over laterally cut records, and their use has permitted both the recorder and reproducer to be greatly improved. Among the changes made are the use of "cathode sputtering" to render the original wax electrically conducting before being electroplated, instead of the previous process of graphiting the wax; and the replacing of the abrasive record of the past with a non-abrasive final record.

The improvements which result are:

1. Noise has been reduced 25 to 30 db.
2. Volume range has been increased from about 25 to 30 db. to about 50 to 60 db.
3. Upper frequency cut-off has been extended nearly an octave to about 9,000 cycles.
4. The playing time for a 12-in. record may be increased from about 4 min. to at least 15 min.
5. The life of the record has been tremendously increased.
6. A more faithful reproduction has been obtained as a result of flatter frequency characteristics and less linear distortion, so that sounds are more distinct, life-like, and clean cut.

The demonstrated results with these records are enhanced by the use of better microphones and much more powerful amplifiers and loud speakers. (A.I.E.E. paper No. 32-84)

## Adequate Wiring of Buildings, an Essential for Good Illumination

By
G. H. Stickney[18]
Walter Sturrock[18]

PROGRESS in securing good illumination in buildings has been seriously impeded within a few years by lack of sufficient wiring capacity, much to the disadvantage of owners and managements. This paper reviews the situation from the point of view of illuminating engineering, in the hope of stimulating interest in the problem, thus promoting wider exemplification of practises which will insure a reasonable prospect of lighting circuits adequate to facilitate proper illumination during the life of a structure.

Fairly definite practises have been established for the lighting of small buildings, and fundamental principles have been established for buildings where the lighting requirements may be more severe. A study of standard illumination levels over the past few years indicates the definite trend toward increased illumination, and the expected continuance of this trend will make inadequate the present wiring of many buildings.

Electrical consumption will doubtless be increased by the number of more or less new lighting applications which are going into use. "Built-in" lighting requiring special construction of walls and ceilings of buildings, or simulated by modified forms of luminaires, is spreading rapidly in this country. Lamps are being used which, in addition to the visible light, supply ultra-violet radiation. Also, consideration must be given to the increased load caused by a variety of devices which are supplied from the lighting circuit.

The quantitative elements of wiring also must be considered, and the existing wiring code should be followed. Specifications which have been prepared should be familiar to all consulting engineers, and subjected to criticism by them. Out of this it is to be hoped there may come generally accepted standards of wiring practise. (A.I.E.E. paper No. 32-86)

## Dynamic Braking of Synchronous Machines

By
C. E. Kilbourne[11]
I. A. Terry[11]

TWO GENERAL electrical methods of quickly stopping synchronous machines are plugging and dynamic braking. Plugging, consisting of reversing the phase rotation of the voltage applied to the armature winding, is subjected to a number of serious objections. Dynamic braking, consisting of short-circuiting the armature through an external resistor and maintaining field excitation, is more desirable and generally will result in quicker stopping.

An analytical treatment of dynamic braking is presented in this paper, and is new to the extent that it treats variable speed short circuits, and presents a method of allowing for saturation. The analysis is carried out both for constant effective excitation, and for variable excitation, and general equations are presented which enable a determination of the time required to stop a synchronous machine.

The agreement of test values with the calculated values is quite good at the point of optimum resistance. This is true of the revolutions to stop as well as of the current-speed and time-speed curves. As the resistance is increased or decreased with respect to the optimum, the agreement is somewhat less satisfactory. (A.I.E.E. paper No. 32-67)

## Induction Motor Versatility—The Nature of Its Applications

By
E. W. Henderson[19]

TODAY the induction motor bids fair to bring about another revolution of ideas as regards its use and capabilities. Heretofore, particularly in respect to the squirrel cage motor, it has been confined to rather restricted fields of application. Its starting characteristics and the need of special starting devices were against it. Now, limited-starting-current motors such as those employing double cage rotors are overcoming these starting objections. The use of these "across-the-line" motors has encouraged the idea of throwing standard motors directly on the line as well as the use of induction motors for applications demanding frequent starting or reversing. Formerly the squirrel cage motor was looked upon as one to be applied only for constant speed service; today there are many applications where the operating range covers wide variations in speed.

The demand for adjustable speed has been met to some extent by the slipring motor and commutator type of motor. There is, how-

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17. Bell Telephone Laboratories, Inc., New York, N. Y.
18. General Electric Company, Nela Park, Cleveland, Ohio.
19. Reliance Electric & Engineering Company, Cleveland, Ohio.

ever, a number of applications of single winding, simple squirrel cage motors, which has been adapted to a great variety of uses. These motors, it is pointed out, may be classified as follows: division I covers the slips of approximately zero to 20 per cent; division II covers slips of from 20 to 70 per cent; and division III covers the range from 70 per cent slip to standstill. In each of these divisions a variety of starting and running characteristics may be secured by proper motor design. Stopping characteristics also are subject to control.

Applications of squirrel cage motors for rapid and oft-repeated reversing or starting duty have been very active lately. For such service the squirrel cage rotor has many advantages over the d-c. armature, due to its lower inertia, and the fact that no vulnerable winding, commutator, brushes, and brush rigging are required. These and other characteristics which may be obtained in the induction motor are constantly widening its field of application. (A.I.E.E. paper No. 32-93)

# Current Propagation in Electric Railway Propulsion Systems

By John Riordan[8]

TRACKS of electric railways, being continuously in contact with the earth, allow current to leak into the earth, the track current thus varying continuously at various points along the length of the track, unlike the currents in other conductors of the propulsion system. This paper aims to present a systematic treatment of current propagation in the tracks with a view to providing a theoretical foundation for the treatment of engineering problems in which the electrical behavior of the tracks as a part of the current-carrying system is important.

Such questions generally involve the impedances of electrified railway propulsion networks of varying degrees of complication and their mutual impedances with other conducting systems. Typical practical problems are the calculation of regulation and efficiency, of short-circuit current magnitude and distribution, of induced voltages in communication circuits exposed to the electrified network, and of the effects upon such quantities of changes in one or more of the network elements. Although the method of treatment set forth is illustrated by certain practical examples, the scope of the paper does not include any detailed development of procedure for the engineering application of the results. The treatment is restricted to systems in which the tracks and other leaky conductors, such as ground wires, may be represented with sufficient accuracy by a single conductor; but it includes track discontinuities due to impedances connected either in series with the tracks or between track and ground.

There are developed the properties of a basic circuit consisting of a parallel conductor of finite length, such as a trolley, connected at its terminals to the track which is continuous and infinite. The track currents and voltages to ground of this circuit are derived and collected conveniently into a single table. The self-impedance of this circuit and mutual impedances with other similar circuits are given. These impedances may be employed in representing the propulsion system in the railway network diagram. The basic circuit may be employed also in the construction of cumulative induction curves for neighboring communication lines. Track discontinuities may be taken into account by superposition upon the basic circuit of properly chosen currents flowing only in track-earth circuits. (A.I.E.E. paper No. 32-92)

# A New High Speed Reactance Relay

By A. R. van C. Warrington[21]

MAINTENANCE of stability on modern interconnected high capacity transmission systems is made considerably easier by the use of relays which not only operate extremely rapidly on line faults, especially three phase short circuits, but refrain from operating on the surges of power which often follow the interruption of the fault current. In this paper a new distance relay is described which, it is stated, seems to go further in the direction of meeting these requirements than anything hitherto described.

The new distance relay operates in the order of one cycle, even on low voltage, and employs reactance as a basis of distance measurement, thereby being free from errors due to the variable resistance of the fault itself. The relay is operated by motor units of the dynamometer type and consequently produces many times the torque per unit of electrical input that could be obtained with the induction disk or plunger type of relay.

The distance measurement is carried out by two reactance ohm-units, one set to operate on faults within a zone reaching nearly to the end of the protected line and the other given a higher setting reaching out well into the neighboring section for which back-up protection is desirable. Faults are distinguished from surge and load conditions by a starting unit which is a very sensitive directional relay having a voltage-restraint which gives it an ohmic characteristic. The design employed for the starting unit provides advantages which can be summarized as follows:

1. Maximum protection against undesirable operation during heavy surges of power between generating sources.
2. Maximum response to fault currents, *i. e.*, maximum directional sensitivity only present when required—at low voltage. This is accomplished without the use of contacts and without excessive burden at any potential, normal or below.
3. Extremely rapid action obtained even at low voltages with sturdy relay parts and with normal travels and contact pressures.

The timing unit consists of a clockwork mechanism controlled by an escapement and operated by means of a d-c. solenoid. The function of the timing unit is to allow tripping of the circuit breaker up to a higher ohmic value and after a suitable time delay if the fault is not near enough to warrant instantaneous tripping; also, to trip after a maximum time interval in case of emergency. (A.I.E.E. paper No. 32-12)

# Operation of Relays From Carrier-Current Coupling Capacitors and Capacitance Transformer Bushings

By J. E. Clem[11] R. E. Cordray[21]

APPLICATION of carrier current communication to transmission lines required the development of coupling capacitors. These coupling capacitors may be used also in combination with transformers to obtain potential from the transmission line. This potential will be suitable for the operation of certain instruments and relays, depending upon burden and accuracy requirements. By the addition of suitable chokes, the coupling capacitors may be used also for carrier current communication. It is the purpose of this paper to describe briefly these coupling capacitors, and to point out means for utilizing them for the purpose of obtaining potential for relaying operation, and to call attention to some applications.

The low voltampere capacity of these potential sources, when it is desired to maintain relatively small phase angle errors, renders them suitable only for supplying relay circuits of low burden. By the use of parallel capacitors, however, the burdens of other relays may be brought within the capacity of these potential sources. Ground directional current relays may be supplied from these sources in certain cases, depending upon the complexity of the relaying for the entire system and the ratio and phase angle errors which may be tolerated. In addition to coupling capacitors, within recent years capacitance transformer bushings have been developed which incorporate a tap for obtaining voltage from the line through the capacitance of the bushings. In general, bushing potential devices are suitable sources for reactance relay potential on voltages of 132 kv. and up, and have been applied successfully at 115 kv. on lines of moderate length. (Pamphlet copies not available.)

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20. Union Electric Light & Power Company, St. Louis, Mo.
21. General Electric Company, Philadelphia, Pa.

# Application of High Speed Relays

By
G. W. Gerrell[20]

CONSTRUCTION of the Osage hydroelectric plant and its interconnection with the existing system of the Union Electric Light & Power Company of St. Louis, Mo., made desirable a study of the relaying schemes as applied for the 66-kv. and 132-kv. transmission lines.

Stability investigations and operating experience definitely indicated the desirability of high speed relays and high speed oil circuit breakers. On the existing system it was possible in a number of cases to use the old oil circuit breakers, rebuilding them for high speed operation.

In the selection of relays for phase-to-phase and three-phase faults, it appeared that during parallel line operation balanced percentage differential relays of the high speed type would offer the simplest and most efficient solution. An analysis of the individual circuits, however, showed that the application of this type of relay was rather limited, and distance relays of the impedance directional type or reactance directional type were required on some of the lines. These two latter types also were used for protection against phase-to-phase and three-phase faults on single lines. Time delay overcurrent relays were used throughout for back-up protection.

For protection against line-to-ground faults, balanced ground current relays were installed in the majority of cases for parallel lines, instantaneous directional ground overcurrent relays being required in two cases for parallel lines. For protection against line-to-ground faults on single lines, either time delay or instantaneous ground relays were used, most of them being of the directional type. Special means were developed for determining the calibration of the reactance and impedance relays.

To date the performance of the high speed relays as applied to this system has been questionable. In favor of these relays it may be said that the relays and the associated high speed circuit breakers have cleared a large number of faults rapidly and correctly, while in their disfavor several cases of operating trouble have occurred. These indicate that the present types of high speed directional relays probably are not applicable to certain types of systems. Further analysis indicates that there are fundamental defects in the design of certain types of high speed relays. Modifications of this particular type of relay, however, are being made. (A.I.E.E. paper No. 32-11)

# The Boric Acid Fuse

By
A. P. Strom[8]
H. L. Rawlins[8]

RECOGNITION of the part played by gas blasts in interrupting arcs in oil circuit breakers and expulsion fuses has opened new avenues for improvements in these devices. The present paper deals with a new type of fuse in which greatly improved performance is obtained by more effective use of the self-generated gas blast.

In this fuse, a form of construction is used which permits the interruption of the smaller ranges of current within a device that is capable of interrupting also heavy short circuits up to 20,000 amperes or more. A special feature of this design is that the lower ranges of current are transferred automatically to, and interrupted in, a small auxiliary fuse bore. While the construction may be used to advantage with any gas generating material, the present design embodies a compressed boric acid liner which has been found to be much more effective than fiber in extinguishing arcs.

Since boric acid evolves water vapor, a condensable gas, it becomes possible to construct a totally enclosed fuse in which the gas blast is discharged into a surface condenser. With such construction, currents of from 5 to 20,000 amperes at 13,000 volts have been interrupted with an electrode separation of less than six inches, using a relatively small condenser. Currents of more than 20,000 amperes have been interrupted by similar fuses of the open type. This type of fuse readily may be designed for various current and voltage ratings. (A.I.E.E. paper No. 32-65)

# Relay Operation From Bushing Potential Devices

By
P. O. Langguth[8]
V. B. Jones[8]

FIELD EXPERIENCE over the last three years establishes the condenser bushing potential device as a reliable and adequate source of potential for the relaying of high voltage systems. The potential device utilizes the inherent potentiometer characteristics of standard condenser bushings used in high voltage circuit breakers and transformers, and depends for its operation on the charging current through the bushing acting as an electrostatic condenser.

Experience shows that potential devices applied within their burden rating will function properly with over-current-directional relays, voltage relays, and distance relays, in various combinations. It is quite possible that the silicon steel device is not sufficiently accurate for some exceptional relays susceptible to phase angle errors, in which cases tests indicate that the hypernik potential device is satisfactory.

Although not so accurate as the potential transformer, the potential device sometimes is more desirable as a source of relay potential. The phase relation between the line voltage and the relay voltage can be easily varied to suit particular system conditions; furthermore, the potential device gives more effective protection with less relay complication than when the potential transformers are connected to the low voltage bus. This being inherently a self-protecting device, no high voltage fuses and switches are required. The successful operation on many large systems, including relaying, indicates definitely the worth of bushing potential devices and the elimination of high voltage potential transformers. The low cost of these devices and the elimination of high voltage potential transformers justify the bushing potential device where usable.

Performance data including curves and oscillograms are given in this paper to illustrate the functioning of directional and impedance relays when energized by potential devices, and typical installations including results of staged field tests are reviewed. (Pamphlet copies not available.)

# Operating Experience With Supervisory Control on the Reading-Philadelphia Suburban Electrification

By
J. E. Pastoret[23]

ALL SUBSTATIONS and switching stations for the Reading suburban electrification are non-attended and are operated by supervisory control. The supervisory control system provides the dispatcher with the following operating features:

1. Control and indication on all circuit breakers and motor operated trolley sectionalizing switches.
2. When an automatic operation occurs, an alarm bell is sounded, proper indication of the position of the unit is given, and a disagreement lamp indicates which unit has operated.
3. An alarm is sounded and an indication is given if any substation battery voltage reaches a predetermined low value; indication is given also when the battery voltage returns to normal.
4. An alarm is sounded and an indication is given if the temperature of any power transformer on the system reaches a predetermined high value; indication is given also when the temperature returns to a safe operating value.
5. All substation bus differential lockout relays are electrically reset by supervisory control.

Supervisory control was selected on the basis of flexibility, speed with which the system can be cleared up at the time of fault, freedom from error, concentration of operation at one point, elimination of divided responsibility, and economy. Two men maintain the equipment which is installed in 21 stations. There has been no trouble experienced from induction, no faulty operations have been performed,

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[22] New York Edison Company, New York, N. Y.
[23] Reading Company, Philadelphia, Pa.

no faulty indications given, and not a single train delay has been caused by failure of the supervisory control equipment. Each benefit attributed to the equipment has been realized fully in operation, proving the adequacy of supervisory control for operating an electrified railway. (A.I.E.E. paper No. 32-14)

## Developments in Two-Wire Supervisory Systems

By
J. H. Oliver[21]

SPECIFICATIONS for a supervisory system have been modified only slightly during the last few years, and usually require the following: reliability, low maintenance, high speed, simplicity, flexibility, minimum connecting wires, and good appearance. The requirement of minimum interconnecting wires especially is important when the control is to be extended any distance.

A general summary of supervisory control schemes using a minimum of connecting wires is as follows:

1. The four-wire synchronous selector system in use for several years is recommended for the control and indication of both large and small stations where four wires are available or can be procured at small expense.

2. The audible selector system is recommended for the control and indication of small switching, pumping, or hydroelectric stations where operation is infrequent and only one pair of open construction wires is available.

3. The two-wire code selector system is recommended for the control and indication of stations having 23 circuits or less where line wires are economically limited to a single pair.

4. The two-wire synchronous selector system is recommended for the control and indication of small or large stations where the distance between the stations is not over fifteen miles and where only two wires are available or where the additional cost (where the wires are rented) prohibits the use of the four-wire synchronous system.

5. The code synchronous system is recommended for control and indication where several stations are located in the same general direction and it is desired to operate the stations over a common set of wires.

6. The audible indication equipment is recommended for small switching stations, pumping stations, etc., where it is desired to obtain a periodic check only on the indication of a maximum of eleven circuit conditions over the telephone company system from any telephone station. (A.I.E.E. paper No. 32-13)

## Report on Telemetering, Supervisory Control and Associated Communication Circuits

A SUBCOMMITTEE of two committees of the Institute, namely, the committee on automatic stations, D. W. Taylor,[25] *chairman*, and the committee on instruments and measurements, E. J. Rutan,[22] *chairman*, has prepared a report which tabulates and describes, from the point of view of the operating engineer or user, telemetering and supervisory control systems in use today.

The tabulation in the telemetering and supervisory control section of the report enables the prospective user who has a certain requirement in mind, for example, the telemetering of a-c. kilowatts, to determine immediately the systems available for that purpose. All proved systems in general use are tabulated with their characteristics such as accuracy and speed of indication, enabling the engineer to select the system or a few systems particularly adapted for individual conditions. Each scheme has included with it data supplying the characteristics of the communication circuits suitable for the purpose; for example, the user may determine if the scheme he has selected can be used with a given loop resistance with a metallic circuit, but cannot be used with a grounded or non-metallic circuit. A description of the communication circuit is given covering such problems as the use of one circuit for more than one purpose (telemetering and talking, for example) and data on grounding, crosstalk, induction, etc., are given. While much of the information is not new, the tabulation and correlating of the data with the communication circuit is new, and much work has been done by the subcommittee in preparing the data on this phase of the subject.

## The Torque Balance Telemeter

By
A. J. Johnston[21]

BY MEANS of the torque balance telemeter it is now possible to indicate or record with instrument speed and accuracy, the value of such quantities as watts, amperes, volts, temperature, pressure, and flow. These indications may be made up to distances of 100 miles. The value of direct current which is used as the translating means is well within the limit stipulated by the telephone companies. Also, the telemeter automatically compensates for variation in line wire resistance, auxiliary supply power voltage, and variations in tube characteristics.

The device consists fundamentally of an instrument mirror located on an operating element and deflecting light from a lamp source through suitable lenses and mirrors onto two photoelectric tubes of the gas-filled type. The latter tubes are connected to the grid potential of a pliotron tube which supplies the current to be transmitted to the receiving end of the telemetering system.

The receiver may be any form of indicating or recording d-c. milliammeter. If desired, two or more receivers may be operated in series by one transmitter. Likewise, when it is desired to totalize the values of two or more quantities, the transmitters may be connected in parallel to a single receiver. (A.I.E.E. paper No. 32-88)

## Application and Performance of Automatic Equipment on the American Gas and Electric System

By
Philip Sporn[24]
Basil Lanphier[24]
H. E. Turner[24]

DESCRIPTIONS of the great variety of applications of automatic equipment throughout the system of the American Gas and Electric Company are contained in this paper. Reasons for the installations are given, and operating experiences are presented.

The history of the development in operation of automatic station equipment on this system leads to the following conclusions:

1. The flexibility and adaptability of the automatic station when properly applied can contribute greatly to improvement of service.

2. The reliability of automatic equipment is at least as good as that of the very best type of operator, and in general is better than that of the average operator, provided the equipment is maintained reasonably.

3. The automatic station is the ideal solution for handling operating problems at all isolated and lonely locations.

4. Properly applied automatic stations will not only improve service but will do so at a reduced cost.

5. Automatic practise is not only adaptable to its usual functions on power systems, but has spread successfully to such functions as coal handling, coal combustion, and frequency control. No doubt additional functions will be taken over by automatic equipment. (A.I.E.E. paper No. 32-89)

## Vibration and Fatigue in Electrical Conductors

By
A. E. Davison[28]
J. A. Ingles[28]
V. M. Martinoff[28]

VIBRATION in electrical conductors is discussed in this paper. Stress is placed upon the necessity for the development of some new types of conductor which will, because of their shape or some inherent quality, resist more successfully than standard sections, the tendency to vibrate and the tendency to fail because of resulting fatigue. A number of appliances have been put forward from time to time which tend to reduce the amount of vibration ordinarily observed in a span. They are usually called dampers. However, there has been very little work done in the study of preventives.

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[24] American Gas & Electric Company, New York, N. Y.

[25] United Engineers and Constructors, Inc., Newark, N. J.

[27] Aluminum Company of America, Massena, N. Y.

[28] Hydro-Electric Power Commission of Ontario, Toronto, Canada.

The research described in this paper covers the placing of various cables with special section in flowing water and calibrating the resulting vibrations. Some types of stranded conductor show a material reduction in the tendency to vibrate. Among those showing the greatest reduction are the twisted triangle, the twisted square, and three-strand wire. Experiments in water show from 50 to 90 per cent reduction in the amplitude of vibration, other things being as near equal as possible.

The experiments reported are considered only as directional, although a few practical conductor shapes approximating the twisted triangle have been developed and are now being tested in air. The practical difficulties which will be encountered in the use of conductors of this general type are discussed. (A.I.E.E. paper No. 32-69)

## Transmission Line Vibration Due to Sleet

By
J. P. DenHartog[8]

PHENOMENA of vibration in transmission lines due to the action of a transverse wind are encountered most frequently at moderate wind velocities (about 5 miles per hr.) and are characterized by rather high frequencies (5 to 15 cycles per sec.) and small amplitudes (up to a few cable diameters). This type of vibration is caused by the "Kármán" vortices forming behind the wire and is well understood.

Another type of disturbance has been observed, which seems to occur with sharp winds of above 20 miles per hr. with great amplitudes (20 ft.), slow frequencies (1 cycle per sec. or slower), and mostly associated with sleet formation on the conductors. This phenomenon has been rightly described as caused by the change in shape of the conductor due to the ice coating and by the consequent change in aerodynamic lift.

It is the object of this paper to give an explanation of the effect and to show how the stability in this respect of a transmission line can be calculated from the results of an aerodynamic test where both the drag (wind force in the direction of the wind) and the lift (wind force perpendicular to wind direction) are determined for various angles of attack. The conclusions reached may be summarized as follows:

1. The slow vibrations of ice-coated transmission lines in a heavy wind can be explained as due to a certain aerodynamic instability.
2. The phenomenon is entirely different from, and has no connection with, the rapid vibrations observed in fair weather at moderate wind velocities.
3. It is shown that instability occurs when the slope of the "lift curve" is greater than the amplitude of the "drag curve."
4. It follows from the theory that a change in the span length or in the tension of the cable does not affect the phenomenon.
5. The behavior of a toy called the "aerial toubillion" is shown to afford a simple test by which the stability of various ice-coated sections can be determined. (A.I.E.E. paper No. 32-91)

## Stress-Strain Studies of Transmission Line Conductors

By
G. W. Stickley[27]

RESULTS of tensile stress-strain tests illustrating the actual behavior of various conductors used in bare overhead transmission lines, and the effect upon this behavior of certain factors such as repeated stressing and lay of the cable, are presented in this paper.

Tests show that stress in transmission line conductors is not proportional to strain throughout the range of stress to which the cable may be subjected, and which in some cases is as high as from 50 to 70 per cent of the ultimate strength. Also, the modulus of a cable cannot correctly be assumed the same as that of a single wire or rod because the actual modulus of elasticity the first time that stress was applied in the various tests was lower than that obtained the second time and usually both were less than the theoretical or commonly assumed values.

In composite cables such as ACSR which are composed of aluminum and steel wires, additional phenomena occur which are not found in tests of cable composed of a single material. These are caused essentially by the difference in extension at the elastic limit of the aluminum and steel. The different distribution of the two materials therefore results before and after initial loading.

It was found also that the actual increase in modulus resulting from application of stress depends upon the magnitude of the stress applied, the amount of increase becoming proportionately less as the value of stress was increased. Repeated application of the same stress caused no further increase after the first application. The initial modulus was affected slightly by the diameter of the coil into which the cable had been wrapped for handling. The actual modulus of a cable depended upon the length of lay of the component wires, the longer the lay the more nearly the modulus approached that of a single wire. In the design of a composite cable such as ACSR consideration is given to this effect by stranding the steel ore with the longest practical lay and the aluminum wires with the shortest possible lay, the result then being that the core carries a maximum share, and the aluminum a minimum share, of the total stress in the cable.

Lines have been designed in which, during erection, the conductors were stressed at a certain high load for several minutes, thus giving the cable its permanent modulus and set. The feasibility of doing this work at the mill was investigated but found impractical because subsequent handling of the cable resulted in the loss of much of the effect produced. (A.I.E.E. paper No. 32-68)

## Vibration of Overhead Transmission Lines

By
R. A. Monroe[29]
R. L. Templin[29]

STUDIES of vibration of overhead conductors have been prosecuted vigorously for several years in laboratory and fields. The importance of magnitude and distribution of stresses in multiple-strand conductors led to the development of a unique method for measuring stresses in vibrating conductors in the laboratory under conditions closely simulating field conditions, and numerous schemes for effecting better stress distribution at conductor supports have been investigated. These tests have been facilitated by the development of special machinery. Field work has been conducted on special outdoor spans, and observations have been made also upon operating lines at widely separated locations.

Among the results which have been secured in these studies are the following:

1. Theoretical formulas expressing relationship between frequency, loop length, tension, and weight agree well with field observations. The Relf and Ower formula for frequency is substantially correct as indicated by tests embracing various cable sizes and wind velocities.
2. Any suspended cable, when conditions are favorable, will vibrate as shown by records of frequency and amplitude for aluminum, copper, steel, and composite types. A feasible reduction in tension will not prevent vibration and would be of value chiefly in decreasing the direct stress.
3. A properly designed damper will reduce the amplitude of vibration to an amount which scarcely is visible. A formula by Bate states that input of energy from the wind varies directly as amplitude; therefore, an effective damper is required to absorb only a small amount of energy.
4. The efficiency of various types of dampers has been determined by comparison of the vibration of damped and undamped spans. The Stockbridge damper gave better results than any other type investigated, is simple in design and construction, has no moving parts, and is easy to install even on hot lines. To perfect the design and extend to range of application, this damper has been subjected to extensive tests.
5. Experiments on eccentric cable shapes and cables of different stranding show that a rough exterior surface reduces amplitude but do not indicate that a vibrationless cable can be evolved.
6. Variation in vertical load at a suspension camp has been measured but was found to be relatively small in magnitude.
7. Armor rods are primarily reinforcement, although they reduce the amplitude of vibration approximately from 10 to 20 per cent.
8. Adequate practical protection against damage from vibration of conductors is afforded by proper use of armor rods or dampers. (A.I.E.E. paper No. 32-90)

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[29] Aluminum Company of America, Pittsburgh, Pa.

# News
## Of Institute and Related Activities

## Summer Convention Program Extended

FINAL arrangements for the 48th annual summer convention of the Institute to be held at Cleveland, Ohio, June 20–24, 1932, now have been made by the Cleveland national convention committee. Advance notices have been mailed by this committee, which requests that all interested parties send in the return cards supplied. These include the advance registration card, one for hotel registration, and another for sports. As previously announced, there will be no registration fee for the main convention program.

In connection with the entertainment features of the convention, there will be a charge of $5 per person, payable upon registration, covering all entertainment features except greens fees. The special feature on Thursday, June 23, at Nela Park, and including various field events, dinner, and dancing, is covered by this fee. This feature extends through the afternoon and evening of one day, replacing the usual formal banquet.

### TECHNICAL SESSIONS

In addition to the technical papers as given in the announcement for the summer convention in ELECTRICAL ENGINEERING for May 1932, p. 346–8, the following papers have been added:

CHARACTERISTICS OF SURGE GENERATORS IN RELATION TO THEIR APPLICATION TO THE SURGE TESTING OF TRANSFORMERS, P. L. Bellaschi, Westinghouse Electric & Mfg. Co.

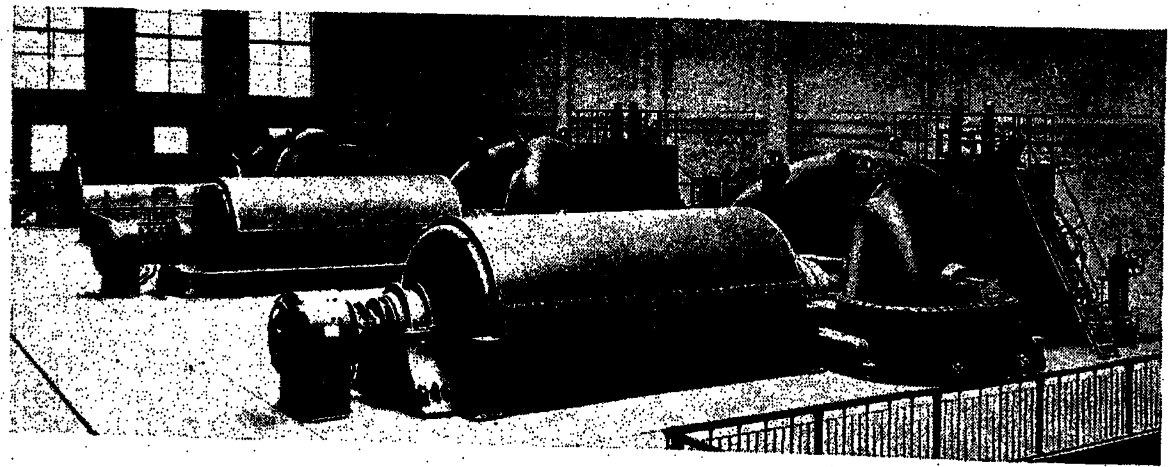
CURRENT PROPAGATION IN ELECTRIC RAILWAY PROPULSION SYSTEMS, John Riordan, American Telephone & Telegraph Co.

REPORT ON TELEMETERING, SUPERVISORY CONTROL AND ASSOCIATED COMMUNICATION CIRCUITS, subcommittee of committee on automatic stations, D. W. Taylor, *chairman*, and committee on instruments and measurements, E. J. Rutan, *chairman*.

The paper by P. L. Bellaschi has been added to the Wednesday morning session on electrical machinery; the paper by John Riordan, to the Thursday morning session on selected subjects and technical committee reports; and the report on telemetering and supervisory control, to the Friday morning session on automatic stations.

One feature of interest in connection with the technical program is that all technical sessions are to be held in the morning, leaving all afternoons free for inspection trips and the various entertainment features.

## Ashtabula Plant to Be Visited During Convention



AMONG the numerous inspection trips arranged for the summer convention of the Institute at Cleveland, Ohio, June 20–24, 1932, is a visit to the Ashtabula steam-electric generating plant of the Cleveland Electric Illuminating Company, the turbine-generator room of which is illustrated above. Three 50,000-kw. units are shown, the first of which was placed in service late in 1930, and the other two in the spring of 1931. These are 1,800-r.p.m. machines generating at 13.2 kv.

## Plans Progressing for Pacific Coast Convention

VANCOUVER, BRITISH COLUMBIA, scene of this year's Pacific Coast convention of the Institute, August 30 to September 2, 1932, has a natural setting difficult to describe adequately. Situated in country striking for its strong contrasts in scenery, it has as well a remarkably temperate climate and excellent facilities for practically every kind of sport and recreation.

In addition to the fine recreational program which the convention committee is preparing, the technical program now practically is completed. Feature topics scheduled for the meeting are:

1. Power generation.
2. Communication.
3. Transportation.

Power generation includes papers on the British Columbia Electric Power System and the Rock Island development on the Columbia River of the Puget Sound Power Company. An interesting discussion on segregation of hydroelectric power costs also is expected. Short-wave radio transmission will be dealt with, and radio links in the British Columbia Telephone Company's system will be described. Railway electrification will be taken up in two papers presenting different angles of the subject. Other topics include corona loss investigations up to 600-kv., zero error current transformers, factory assemblies for substations, metering of symmetrical components, triple harmonic residual effects in transmission systems, and other equally interesting subjects.

With regard to hotel accommodation, very reasonable rates have been arranged as follows with the Hotel Vancouver, convention headquarters:

| | |
|---|---|
| Double bedroom with bath.......... | $6.00 |
| Single bedroom with bath............ | 4.00 |
| Double bedroom without bath....... | 5.00 |
| Single bedroom without bath........ | 3.00 |

Hotel officials are cooperating with the committee and in addition to reserving a number of rooms for the convenience of Institute members, arrangements have been made to insure the comfort of all visitors.

No special travel rates have been arranged, since at the time of the convention the summer rates will be in force. Consideration should be given also to the fact that a holiday spent in British Columbia will be cheaper this year than usual, owing to the present rate of exchange.

## Directors Meet at National Headquarters

The regular meeting of the board of directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, May 20, 1932.

Present were: *President*—C. E. Skinner, East Pittsburgh, Pa.; *Past-President*—W. S. Lee, Charlotte, N. C.; *Vice-Presidents*—H. P. Charlesworth, New York, N. Y.; W. E. Freeman, Lexington, Ky.; W. B. Kouwenhoven, Baltimore, Md.; I. E. Moultrop, Boston, Mass.; P. H. Patton, Omaha, Neb.; G. C. Shaad, Lawrence, Kans.; *Directors*—L. W. Chubb, East Pittsburgh, Pa.; A. B. Cooper, Toronto, Ont.; J. Allen Johnson, Buffalo, N. Y.; A. E. Knowlton, New York, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New York, N. Y.; R. H. Tapscott, New York, N. Y.; H. R. Woodrow, New York, N. Y.; *National treasurer*—W. I. Slichter, New York, N. Y.; *Assistant national secretary*—H. H. Henline, New York, N. Y.

Minutes of the meeting of January 27, 1932, were approved.

Resolutions formulated by the executive committee in March, in memory of Past-President Harold B. Smith and National Secretary F. L. Hutchinson, were adopted as resolutions of the board. Tributes to Mr. Hutchinson from Sections and individuals were read.

Minutes of the meeting of the executive committee held March 9, 1932, were presented, and the actions taken at that meeting were ratified. The following actions of the executive committee on applications also were ratified: 1 applicant was elected to the grade of Fellow and 8 applicants to the grade of Member; 4 were transferred to the grade of Member; 233 were elected to the grade of Associate; 91 Students were enrolled.

Reports of the April 13 and May 18 meetings of the board of examiners were presented and the actions taken at those meetings were approved. Upon the recommendation of the board of examiners, 6 applicants were elected to the grade of Member and 13 were transferred to the grade of Member; 163 Associates were elected; 148 Students were enrolled.

The assistant national secretary reported 2,338 members in arrears for dues for the year ended April 30, 1932, and was directed to remove the names from the mailing list after the distribution of the June and July issues of ELECTRICAL ENGINEERING, and to employ the usual methods of collecting the dues and restoring the members to the active membership list. He also reported that on April 30, 1932, 1,018 members (6 Fellows, 85 Members, and 927 Associates) were dropped from the membership list, for non-payment of dues for the fiscal year which ended April 30, 1931.

The board of directors ratified the action of the finance committee in approving, for payment, monthly bills amounting to $22,214.12.

Upon the recommendation of the standards committee, approval was given, as sponsor, of three reports on symbols developed by the A.S.A. sectional committee on scientific and engineering symbols and abbreviations, as follows: "Graphical Symbols Used in Radio," "Graphical Symbols Used for Electric Power and Wiring," and "Graphical Symbols Used for Electric Traction Including Railway Signaling."

The report of the committee on award of institute prizes covering the awards made for the year 1931 was presented, as published elsewhere in this issue.

The annual report of the board of directors for the fiscal year ended April 30, 1932, as prepared under the direction of the assistant national secretary, was considered and approved for presentation at the Annual Meeting of the Institute, Cleveland, June 20.

The national treasurer presented a report covering the fiscal year just closed. Annual reports were received from the general standing committees (exclusive of the technical committees' reports, which will be presented at the summer convention in June and are published elsewhere in this issue). Abstracts of these reports were incorporated in the annual report of the board of directors.

The board by unanimous action appointed H. H. Henline as acting national secretary of the Institute, beginning June 1, 1932.

Representatives were appointed as follows: Bancroft Gherardi to the John Fritz Medal Board of Award, succeeding the late Prof. Harold B. Smith, and H. H. Henline to the Assembly of American Engineering Council, as successor to F. L. Hutchinson.

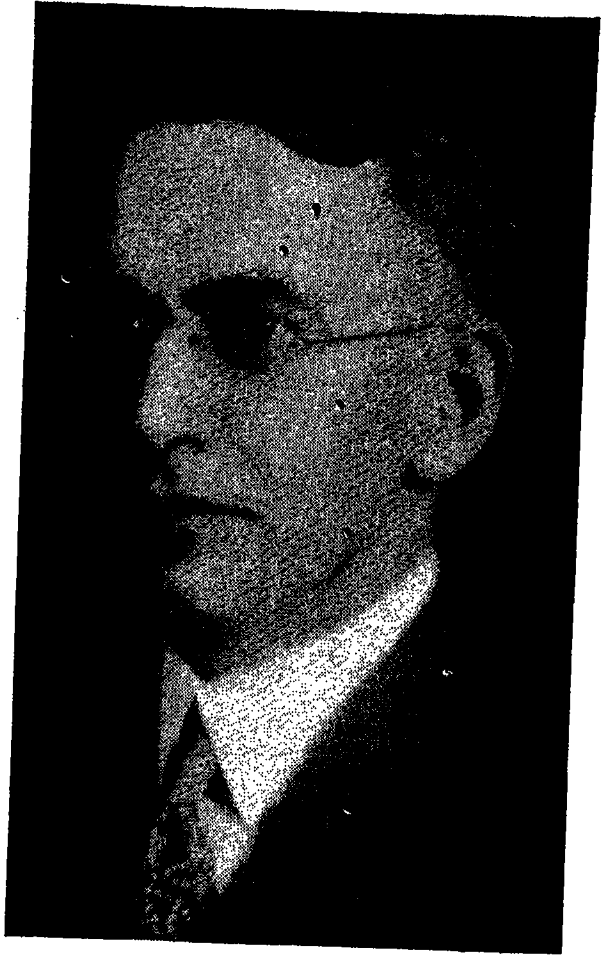
Announcement was made of the appointment of Institute representatives upon a joint committee of the United Engineering Trustees, Inc., and the national societies of civil, mining and metallurgical, mechanical, and electrical engineers to consider the subject of coordination of the various engineering organizations.

It was voted to hold the June meeting of the board of directors in Cleveland, on Wednesday, June 22.

Other matters were discussed, reference to which may be found in this and other issues of ELECTRICAL ENGINEERING.

## H. H. Henline Appointed Acting National Secretary

By unanimous action of the board of directors of the American Institute of Electrical Engineers at its regular meeting held May 20, 1932, Henry Harrison Henline, since 1927 assistant national secretary, became acting national secretary of the Institute, effective June 1. In his new capacity, Mr. Henline takes over the executive duties for twenty years performed by the late F. L. Hutchinson.



H. H. Henline

For many years Mr. Henline has been interested in and actively associated with Institute work and, prior to his affiliation with the national headquarters staff, he made numerous contributions to its published technical works. He was elected to membership in 1919, and has served as chairman of the San Francisco Section (1922–23); faculty counselor for the Student Branch at Stanford University, Calif., (1926); chairman of the Committee on Student Activities for the Pacific District—California, Arizona, Nevada—(1926); and as a member of the Sections committee (1923–27). Since joining the staff January 1, 1927, Mr. Henline has served as the Institute's representative on the American Year Book Advisory Board (1927–32); the American Standards Association (alternate representative 1929–32); Joint Committee on State Engineering Councils (1932–33); and has served on the Institute's Education committee (1929–32). He now becomes a representative of the Institute on the Assembly of the American Engineering Council. While he has been on the headquarters staff, Mr. Henline has participated in many phases of the Institute's work, but has devoted his principal attention to the work of its 60 Sections and 109 Branches.

Mr. Henline was born at Colfax, Ill., March 12, 1889, and after attending local grammar and high schools entered the University of Illinois in 1910, graduating in 1914 with the degree of Bachelor of Science in Electrical Engineering. After serving for a year as instructor in science and mathematics in the Oktaka, Okla., high school and as director of athletics for the Oktaka public schools, he entered the Chicago Central Station Institute of the Commonwealth Edison Company, graduating in 1916 and entering the commercial engineering department of the Illinois Maintenance Company of Chicago.

Joining the faculty of Stanford University in 1917 as an instructor, Mr. Henline later was promoted to assistant professor (1920) and to associate professor (1924) in the department of electrical engineering. In his work of instruction Mr. Henline gave at various times many courses in electrical engineering subjects, and was in charge of the machinery laboratory for five years and in charge of communication engineering for three years. He also was associated with

Dr. Harris J. Ryan in some of the high-voltage research that has made Stanford famous. He is author of a paper on engineering education, a paper on a standard-frequency radio station, and joint author of three papers on subjects relating to high-voltage electric power transmission.

Aside from the affiliations already given, Mr. Henline's organization memberships include the Society for the Promotion of Engineering Education, Institute of Radio Engineers (*Member*), American Association for the Advancement of Science (*Fellow*), Eta Kappa Nu, and Sigmi Xi.

# North Eastern District Holds Eighth Annual Meeting at Providence

In CONNECTION with its eighth annual meeting held May 4–7 at the Providence (R. I.) Biltmore Hotel, the North Eastern District, originator in 1924 of the District meeting idea, successfully conducted another possibly significant experiment in connection with the conduct of such meetings. Largely as an economy measure, but partly also in the interest of promoting better technical sessions, the District committee dispensed with the traditional advance pamphlet copies of the technical papers presented. As for economy, a substantial reduction was achieved in the cost of the meeting to the Institute; as for the effect on technical sessions, they were obviously improved by the more carefully prepared presentations of the various authors.

Accepting frankly the necessity for economy, the District meeting committee sought diligently for ways and means of achieving the desired reduction in meeting expense that would interfere the least with a successful meeting program, and at the same time best serve the average member of the Institute. The committee considered many possibilities, including a reduction in the number of meeting sessions and a reduction in the number of papers presented per session, but finally decided that the best interests of all concerned would be served most effectively by dispensing instead with the traditional publication of pamphlet copies for advance distribution and for circulation at the meeting. Also supporting this decision was the fact that the substance of the more important papers of general interest would be circulated throughout the membership in current issues of Electrical Engineering (in addition to advance publication therein of comprehensive abstracts of all papers), and that the full text and related discussion of all papers so recommended by the technical program committee would be scheduled as usual for inclusion in the September issue of the Transactions.

Further influencing the North Eastern District meeting committee's decision to experiment with the Providence meeting was a strong and growing belief held by a good many active Institute members that the traditional habit of having convention sessions depend primarily upon the presence of pamphlet copies distributed throughout the audience is seriously injuring the quality and general interest value of the sessions. Knowing that the audience facing them either is reading or has read the dissertation about to be presented has caused most authors to give exceedingly sketchy and unfortunately uninteresting oral résumés of their papers. This situation was notably absent at the Providence meeting where nearly every author made an interesting and understandable presentation of his subject. Many, speaking upon the more complicated subjects, simplified and enlivened their presentation by strategic use of lantern slides reproducing diagrams, tabulations, and other illustrations throughtfully coordinated with their oral presentations.

As for the effect upon those attending the sessions, the Providence experiment produced reactions ranging all the way from one extreme to the other, as might be expected. Some few were notably antagonistic to the idea, while a few were equally ardently and unqualifiedly in favor of its wide adoption. Perhaps the principal significance of the experiment lies in the facts that discussion was active, pertinent, and interesting; and that the expressed opinion of many persons attending the various sessions was preponderantly to the effect that the sessions were notably improved. While there was no official expression of opinion in connection with the experiment, the opinion was vigorously expressed to the effect that the full possibility of benefits should be plumbed by a further prosecution of the experiment in connection with other meetings.

## Technical Sessions

The four general technical sessions embraced papers as announced in the April issue of Electrical Engineering: various electrophysical subjects, presided over by Dr. Vannevar Bush; induction and synchronous motor problems, presided over by P. L. Alger; a symposium on traffic control, guided by Prof. H. M. Turner (Yale); and a discussion of the theory involved in electric power transmission, with P. H. Chase presiding. In addition, one entire technical session was given over to the District student convention, with H. L. Wood, senior student from the university of New Hampshire, presiding. Papers presented by students were:

1. The Thyratron Tube for Field Excitation of Electric Generators and Motors, George Andrews, Rhode Island State College.
2. Communication at Five Meters, E. M. Dukat and A. V. Nelson, Yale University.
3. Design and Construction of a Television Receiver, D. W. Mack, University of New Hampshire.
4. Development of a Practical Television Receiver, W. S. Bachman and E. M. Wolf, Cornell University.
5. Electrical Characteristics of a High Voltage Testing Transformer, Messrs. Reiter, Jessel, and Quan, Harvard University.
6. Electricity in Modern Medicine, E. W. Schafer, Massachusetts Institute of Technology.

Sharing honors with the general-interest session devoted to traffic control, the student session enjoyed an attendance in excess of 100, about twice the attendance at the more technical sessions. William S. Lee, past-president of the Institute, was the feature speaker at the student session. The dual theme of his address was directed toward urging student engineers to give attention to economic and sociological subjects in addition to their technical studies, and to encourage them to face the present economic upheaval with the realization that valuable and important opportunities await the aggressive individual and organization.

At the close of the student session the judges reported prize winning papers as follows:

First, D. W. Mack, University of New Hampshire;

Second, E. M. Dukat and A. V. Nelson, Yale University;

Third, E. W. Schafer, Massachusetts Institute of Technology.

## Entertainment

Entertainment features and inspection trips were well planned and executed for both men and women. In addition to local points of historic interest, many enjoyed the trips through the plants of the Gorham Manufacturing Company, and the U. S. Rubber Company, and to the properties of the Narragansett Electric Company and the United Electric Railways Company. Women guests enjoyed a luncheon at the Wannamoisett Country Club, and several small parties took the opportunity to motor to Newport and other nearby points of interest. By courtesy of the Wannamoisett Country Club, members and guests attending the meeting enjoyed golfing privileges.

At an informal bridge party held Wednesday evening, President Skinner rather unexpectedly found himself in the rôle of a travel lecturer. Extemporaneously he took his highly attentive audience on a most interesting movie-monologue trip along the route that he recently had followed through Mexico and into Yucatan. The social climax of the District meeting came Thursday evening with the annual banquet and dance. There again Past-President William S. Lee delivered one of his inimitable discourses on matters non-technical, including poetry.

The Providence District meeting was handled under the very active generalship of District Vice-President I. E. Moultrop of Boston, who served as chairman of the District meeting committee. With Mr. Moultrop on that committee were A. C. Stevens, Schenectady, District secretary-treasurer; C. W. Henderson, chairman of the Syracuse Section; O. W. Briden, secretary of the Providence Section; R. W. Graham, chairman of the Niagara-Frontier Section; W. S. Maddocks, chairman of the Providence Section; J. P. McCann, chairman Worcester Section; R. G. Warner, chairman Connecticut Section; and F. C. Young, chairman Rochester Section.

Under the active, driving leadership of Vice-President Moultrop and Chairman Maddocks of the local committee, the various Providence sessions were conducted rigidly on the time schedule given in the program. When discussion lagged below a satisfactory minimum it frequently was stimulated and when it began to exceed the bounds of the program schedule it was promptly called to a halt. Punctuality was the keynote of many of Vice-President Moultrop's several and pertinent comments, and it paid its dividend in the conduct of the sessions.

As chairman of the local committee, William S. Maddocks carried the major load of work in connection with the Providence meeting. Associated with Mr. Maddocks on that committee were O. W. Briden, in charge of hotels and registration; R. W. Herrick, in charge of entertainment features; Mrs. R. W. Herrick, in charge of women's entertainment; J. W. Keeney, in charge of finance; L. P. Kenneally, in charge of publicity; J. C. B. Washburn, in charge of inspection trips.

In spite of the highly specialized character of several of the sessions, a total of 252 persons attended the meeting according to the official registration (registration fee $1; 50 cents for students). These were grouped as follows:

| | |
|---|---|
| Members | 134 |
| Registered guests | 33 |
| Women | 20 |
| Students | 60 |
| Student guests | 5 |
| Total | 252 |

# 1932 Lamme Medal Nominations Due Nov. 1

SPECIAL attention is directed to the fact that the names of Institute members who are considered eligible for the Lamme Medal, to be awarded in the fall of 1932, may be submitted by any member in accordance with Section 1 of Article VI of the By-laws of the Lamme Medal committee, as quoted in the following:

> The committee shall cause to be published in one or more issues of ELECTRICAL ENGINEERING, or of its successors, each year, preferably including the June issue, a statement regarding the "Lamme Medal" and an invitation for any member to present to the national secretary of the Institute by November 1, the name of a member as a nominee for the medal, accompanied by a statement of his "meritorious achievement" and the names of at least three engineers of standing who are familiar with the achievement.

Each nomination should give concisely the specific grounds upon which the award is proposed, and also a complete detailed statement of the achievements of the nominee, to enable the committee to determine its significance as compared with the achievements of other nominees. If the work of the nominee has been of a somewhat general character in cooperation with others, specific information should be given regarding his individual contributions. Names of endorsers should be given as specified above.

The Lamme Medal, founded as a result of a bequest of the late Benjamin Garver Lamme, chief engineer of the Westinghouse Electric and Manufacturing Company (deceased July 8, 1924), provides for the annual award by the Institute of a gold medal—together with bronze replica thereof—to a member of the A.I.E.E. "who has shown meritorious achievement in the development of electrical apparatus or machinery"; and for the award of two such medals in some years if the accumulation of funds warrants.

The fourth (1931) Lamme Medal has been awarded to Giuseppe Faccioli (F'12) consulting engineer (retired), General Electric Company, Pittsfield, Mass., "for his contributions to the development and standardization of high-voltage oil-filled bushings, capacitors, lightning arresters, and numerous features in high voltage transformers and power transmission." Presentation will be made during the summer convention at Cleveland, Ohio, June 20–24, 1932.

# Electrical Congress to Meet at Paris, July 4-12

On the occasion of the 50th anniversary of the first International Congress of Electricity, the Société Francaise des Electriciens, the Société Francaise de Physique, the Comité Electrotechnique Francais, and the Union des Syndicats de l'Electricité are organizing, under the auspices of the Commission Electrotechnique Internationale an "International Congress of Electricity," which will convene in Paris, Monday, July 4, 1932. The Congress is open to all persons who wish to participate either in a personal or official capacity.

All those wishing to join must advise the head office of the Congress at 134, Boulevard Haussmann, Paris, before June 15, and must remit at the same time one of the following sums:

1. Those who make a contribution of at least 1,000 French francs will be registered as *benefactor members.*
2. Those who pay a membership fee of 250 French francs will be registered as *subscribing members.*
3. Those who belong to the families of Congress members and who pay a membership fee of 50 French francs will be registered as *related members.*

All payments must be drawn to the order of the Société Francaise des Electriciens, who is responsible for the treasury department.

Statements of the work of the Congress will be published in French, and will comprise the text of reports and papers and the reproduction, as exact as possible, of discussions. The transactions will be collected together in several volumes, and in due course interested parties will be advised of the distribution of the work of the thirteen Sections within these different volumes.

Whether or not they attend in person, Benefactor members will be entitled to receive free of charge the entire collection of transactions and, if desired, may take advantage of a discount of 25 per cent on the normal selling price for the purchase of supplementary volumes. Similarly, Subscribing members will be entitled to receive free of charge the volume or volumes containing the transactions of any one Section and can purchase, with a reduction of 25 per cent on the normal selling price, all or part of other volumes containing the transactions.

All persons particularly interested and desiring further information should at once

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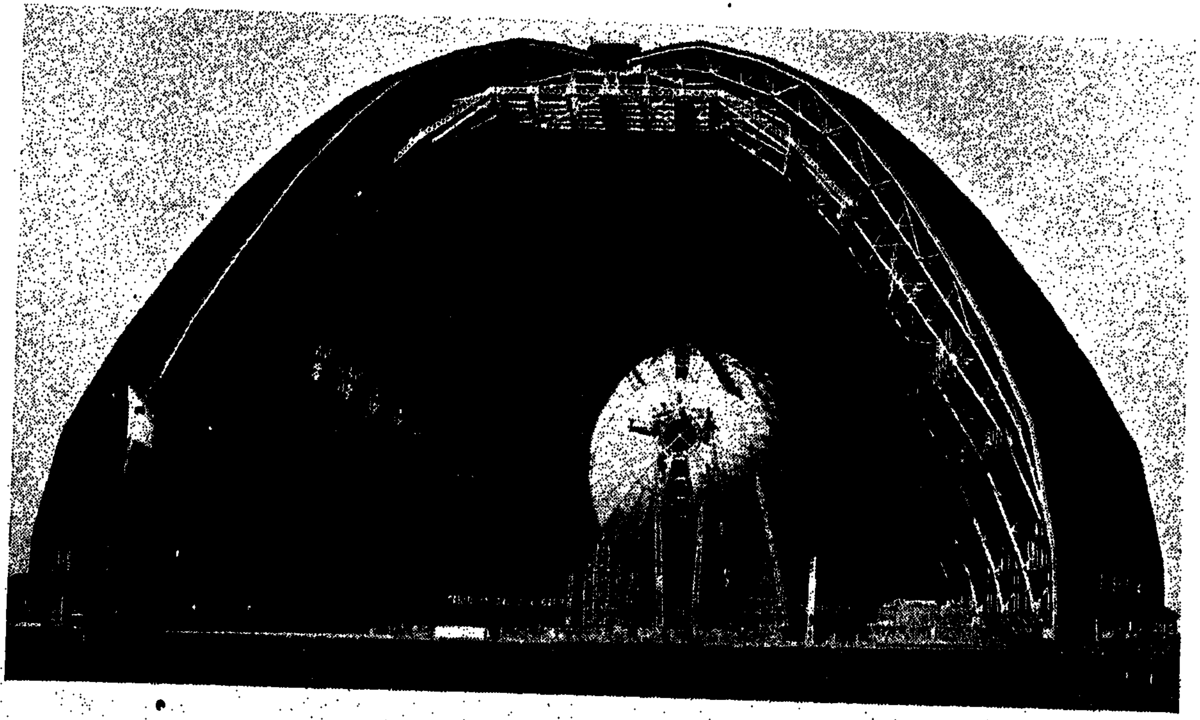
# Goodyear Zeppelin Dock—On Convention Program



CONSIDERABLE popular interest has been evidenced in the inspection trip to Akron, Ohio, which is to take place during the coming summer convention of the Institute in Cleveland, June 20–24, 1932. During this trip a visit will be made to the hangars of the Goodyear Zeppelin Corporation, where the ZR-5 is in process of construction. The ZR-5 is still larger than its sister ship the giant dirigible "Akron," completed there last year. This trip will include also tours of any one of the three large rubber manufacturing plants in Akron; and following a supper at the Mayflower Hotel, the Barberton plant and laboratory of the Ohio Insulator Company will be visited. The outdoor laboratories of this company provide facilities for testing up to 1,000,000 volts, and insure an exhibition which will be instructive and interesting to both the engineers and women guests.

correspond directly with Dr. Harold Pender, Dean, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa.

Technical activities are divided into thirteen Sections as follows:

1. Electrical and magnetic science. General theories. Insulators. Conductors. Radioactivity. Magnetic bodies.
2. Electrical measurements: (a) Units and standards; absolute electrical measures. (b) Laboratory measurements; industrial measurements and experiments with machines.
3. Production and transformation of electrical energy.
4. Transmission and distribution of electrical energy.
5. Electrical traction. Mechanical applications.
6. Electric lighting. Photometry.
7. Electrochemistry. Electrometallurgy. Batteries and accumulators.
8. Telecommunications by wire (distant communications by wire).
9. High frequency current phenomena. (a) Radioelectricity. (b) Radio communications.
10. Radiobiology. Electrobiology.
11. Atmospheric electricity. Terrestrial magnetism.
12. Various applications of electricity.
13. Teaching and history of electricity.

# Institute Prize Awards Announced for 1931 Papers

FOUR national prizes for papers presented during the calendar year 1931 have been announced by the committee on award of Institute prizes, which consists of W. H. Harrison (F'31) chairman, L. W. Chubb (F'21), A. E. Knowlton (F'30) and E. B. Meyer (F'27). These prizes in each case consist of $100 in cash and a suitable certificate; in cases of joint authorship the cash is divided. Personal presentation of the prizes will take place at the opening session of the Institute's summer convention at Cleveland, Ohio, June 20–24, 1932.

District prizes as announced by seven Districts include fifteen awards of $25 each, together with appropriate certificates. As in the case of the national prizes, where there is a joint authorship the cash awards are divided.

## NATIONAL PRIZES

### BEST PAPERS

Prize for best paper in engineering practise, awarded jointly to authors of papers in symposium on coordination of power and telephone plant, composed of four parts as follows: "Trends in Telephone and Power Practise as Affecting Coordination" by W. H. Harrison (F'31) and A. E. Silver (F'26); "Status of Joint Development and Research on Noise Frequency Induction" by H. L. Wills (A'30) and O. B. Blackwell (F'17); "Status of Joint Development and Research on Low-Frequency Induction" by R. N. Conwell (F'31) and H. S. Warren (F'13); and "Status of Cooperative Work on Joint Use of Poles" by J. C. Martin (A'12) and H. L. Huber (M'23). This symposium was presented at the winter convention, New York, January 26–30, 1931.

Honorable mention was made of the following papers: "Synchronous Motor With Phase-Connected Damper Winding for High-Torque Loads" by M. A. Hyde, Jr. (A'27), presented at the winter convention, New York, January 26–30, 1931; and "Economics of High Voltage Cable" by D. W. Roper (F'14) presented at summer convention, Asheville, N. C., June 22–26, 1931.

Prize for best paper in theory and research, awarded to L. V. Bewley (A'27) for his paper "Transient Oscillations in Distributed Circuits With Special Reference to Transformer Windings" presented at summer convention, Asheville, N. C., June 22–26, 1931.

Honorable mention was made of the following papers: "Calculation of Synchronous Machine Constants—Reactances and Time Constants Affecting Transient Characteristics" by L. A. Kilgore (A'29) presented at the summer convention, Asheville, N. C., June 22–26, 1931; "Submarine Cable Telegraphy: Influence of Interference" by J. W. Milnor (F'30) presented at the winter convention, New York, January 26–30, 1931; and "An Experimental Lightning Protector for Insulators" by J. J. Torok (A'27) presented at the winter convention, New York, January 26–30, 1931.

No prize was awarded in the field of public relations and education.

### INITIAL PAPER

Prize for initial paper awarded to Ernst Weber (A'31) for his paper "Field Transients in Magnetic Systems" presented at the summer convention, Asheville, N. C., June 22–26, 1931.

Honorable mention was made of the following papers: "Extinction of Short A-C. Arcs" by T. E. Browne, Jr. (A'31) presented at the summer convention, Asheville, N. C., June 22–26, 1931; "The San Francisco-Los Angeles Section of the Pacific Coast Telephone Cable Network" by E. M. Calderwood (M'24) and D. F. Smith (A'31) presented at Pacific Coast convention, Lake Tahoe, Calif., August 25–28, 1931, and "Temperatures in Electric Power Cables Under Variable Loading" by E. A. Church (A'29) presented at the North Eastern District meeting, Rochester, N. Y., April 29–May 2, 1931.

### BRANCH PAPER

Prize for branch paper awarded to J. R. Batcheller for his paper "Abridged Method of Testing Welds" presented at the joint meeting of the Portland Section and Oregon State College Branch, May 23, 1931.

Honorable mention was made of the following papers: "Accumulation of High-Potential Static Charges on Transmission Lines During Sand Storms" by C. E. Houston, presented at the South West District Meeting, Kansas City, Mo., October 22–24, 1931; and "Influence of Preservatives on the Dielectric Strength of Wood" by C. B. Parsons and M. H. Tipton, presented at a joint meeting of the Portland Section and Oregon State College Branch, May 23, 1931, and at the Pacific Coast convention, Lake Tahoe, Calif., August 25–28, 1931.

## DISTRICT PRIZES

### DISTRICT No. 1

Prize for best paper awarded to P. H. Moon (M'29) for his paper "The Theory of Thermal Breakdown of Solid Dielectrics" presented at the North Eastern District meeting, Rochester, N. Y., April 29–May 2, 1931.

Prize for initial paper awarded to E. A. Church (A'29) for his paper "Temperatures in Electric Power Cables Under Variable Loading" presented at the North Eastern District meeting, Rochester, N. Y., April 29–May 2, 1931.

Prize for Branch paper awarded jointly to D. C. Robinson and R. W. Stone for their paper "A Study of Torque-Time and Slip-Time Relations of an Induction Motor Flywheel Set Operating on a Mine Hoist" presented at the North Eastern District meeting, Rochester, N. Y., April 29–May 2, 1931.

Honorable mention was made of the paper "The Theory of the Capacitance Potentiometer" by A. W. Moon and W. B. Brainard, presented at the North Eastern District meeting, Rochester, N. Y., April 29–May 2, 1931.

### DISTRICT No. 2

Prize for best paper awarded to W. P. Taylor (A'26) for his paper "Locating Power Cable Faults by Means of a Constant-Current Transformer With Short-Circuiting Switch" presented at a meeting of the Baltimore Section, May 15, 1931.

Prize for initial paper awarded to W. P. Taylor (A'26) for his paper "Locating Power Cable Faults by Means of a Constant-Current Transformer With Short-Circuiting Switch" presented at a meeting of the Baltimore Section, May 15, 1931.

### DISTRICT No. 6

Prize for Branch paper awarded jointly to C. A. Church and N. R. Damon for their paper "New Ideas for High-Voltage Circuit Breakers" presented at a joint meeting of the Denver Section and University of Colorado Branch, April 24, 1931.

### DISTRICT No. 7

Prize for Branch paper awarded to C. E. Houston (A'32) for "Accumulation of High-Potential Static Charges on Transmission Lines During Sand Storms" presented at the South West District meeting, Kansas City, Mo., October 22–24, 1931.

### DISTRICT No. 8

Prize for best paper awarded to W. S. Peterson (M'29) for his paper "Calculation of Dynamic Power Limit of Transmission System During Three-Phase Faults" presented at a meeting of the Los Angeles Section, February 17, 1931.

Prize for initial paper awarded to V. A. Hoover (A'32) for his paper "Correlation of Induction Motor Design Factors" presented at the Pacific Coast convention, Lake Tahoe, Calif., August 25–28, 1931.

Prize for Branch paper awarded to E. W. Palmrose for his paper "Vacuum Tube Voltage Regulators" presented at Pacific Coast convention, Lake Tahoe, Calif., August 25–28, 1931.

### DISTRICT No. 9

Prize for best paper awarded to A. Shipek (M'29) for his paper "Analysis of Distribution Substation Costs" presented at a meeting of the Seattle Section, May 19, 1931.

Prize for initial paper awarded to J. L. Watson (A'17) and R. C. Gleeson for their paper "A Special Application of the Potentiometer Principle" presented at a meeting of the Portland Section, December 8, 1931.

Prize for Branch paper awarded to J. R. Batcheller for his paper "Abridged Method of Testing Welds" presented at a joint meeting of the Portland Section and Oregon State College Branch, May 23, 1931.

### DISTRICT No. 10

Prize for best paper awarded to G. L. Lillie (A'21) for his paper "Factors in Design of 115-230-Volt Distribution in a Modern Residential District" presented at a meeting of the Toronto Section, March 27, 1931.

Prize for initial paper awarded to G. L. Lillie (A'21) for his paper "Factors in Design of 115-230-Volt Distribution in a Modern Residential District" presented at a meeting of the Toronto Section, March 27, 1931.

**Plans for the Allocation of Sales Effort.**—As an aid in planning the approach to that portion of the industrial market found in manufacturing plants, the United States Department of Commerce recently released a bulletin "A Basis for Establishing Industrial Sales Territories." In announcing the bulletin, the department stated "To the experienced analyst this material will mean more up-to-date data upon which to adjust and check his present plan of allocating sales effort. However, to those charged with the responsibility of sales promotion in firms which have not established a marketing research department, the data undoubtedly will provide an inexpensive method of establishing quickly a fairly accurate marketing program." Copies may be purchased at 10 cents each from the Supt. of Documents, Govt. Printing Office, Washington, D. C.

## California Approves the Common Neutral

The use of a single combined neutral conductor for electric power distribution circuits operating at a potential of 5 kv. or less, has been approved by the California Railroad Commission for overhead construction, wherever feasible within that state, according to a news item in the May 1, 1932, issue of *Electrical West*. This decision comes after two and one-half years of intensive and extensive study and field tests, conducted under the supervision of the commission and with the cooperation of power and communication utilities and the National Electric Light Association. C. T. Mess (M'29) supervised the work for the commission.

One of the principal controversial points settled by the investigation and subsequent decision was the matter of telephone interference that might be caused by the new type of construction. The matter of safety was given close attention also, resulting in findings that, under the commission's construction specifications, the common-neutral system may be expected to be at least as safe for employees and the general public as the separate-neutral construction, and in many cases safer.

## Summer School for Engineering Teachers

Maintaining its previous practise, the Society for the Promotion of Engineering Education is planning to hold two summer school sessions for engineering teachers during July of this year. One session will be devoted to the study of economics and is to be held at Stevens Institute of Technology, Hoboken, N. J., July 5–21, 1932; a session on English is to be held at the Ohio State University, Columbus, Ohio, July 11–28, 1932. A registration fee of $10 will be charged for each session. Room and board at Stevens will be $50 per person for the period of the session; at Ohio State, $42 per person for the session. In both cases special arrangements will be made for those teachers who are accompanied by their wives.

Improvement of the teaching of engineering is stated as the general purpose of these sessions. Each session will be devoted to a study of the methods of teaching its particular subject or division of the engineering curriculum. Further information may be had from Frederic L. Bishop (A'13), secy., University of Pittsburgh, Pittsburgh, Pa.

## Electrification Report Issued

**Length of Railroad Track Electrified**

| Country | Miles Route | Miles Main Track | Miles All Tracks |
|---|---|---|---|
| United States..... | 2,055 | 3,597 | 4,911 |
| Switzerland....... | 1,542 | 2,105 | 2,929 |
| Italy............ | 1,079 | 1,620 | 2,218 |
| France........... | 1,046 | 1,736 | 2,234 |
| Germany.......... | 972 | 1,647 | 2,373 |
| Sweden........... | 726 | 791 | 1,039 |
| Austria.......... | 564 | 794 | 927 |
| Great Britain..... | 474 | 1,122 | 1,234 |
| Spain............ | 369 | 560 | 650 |
| Australia......... | 261 | 568 | 701 |
| Brazil........... | 251 | 272 | 319 |
| Japan............ | 248 | 441 | 569 |
| India............ | 222 | 455 | 689 |
| Chile............ | 208 | 242 | 365 |
| World total..... | 11,318 | 17,728 | 23,567 |

Electrification of steam railways throughout the world is covered exhaustively in the latest report of the railway electrification committee of the National Electric Light Association. This report is the fifth the committee has issued since a detailed study of steam railroad electrification was begun in 1926. Britton I. Budd, president of the Public Service Company of Northern Illinois, is chairman of the committee, and H. H. Field (A'14, M'28) is secretary.

The length of railroad track electrified, summarized in the accompanying table, is analyzed for the various countries. Existing electrifications are described, and among the new projects discussed are those of the Lackawanna, Reading, New York Central, and Pennsylvania railroads. After analyzing conditions in other countries, the report concludes with a study of the methods by which power is supplied to all the electrifications in the United States.

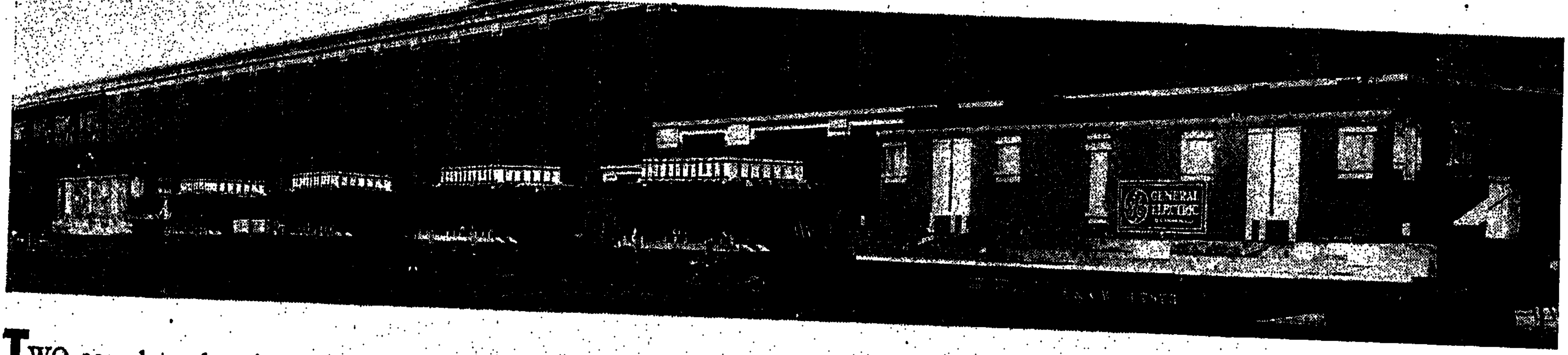
## Statistics on Consumer Markets

Newest data available indicating the location, size, and purchasing power of domestic markets for the products of American industry are presented in a report "General Consumer Market Statistics," made public by the Department of Commerce April 14, 1932. The report is published as the first supplement to the "Market Data Handbook of the United States" recently made available, and brings up to date the statistical information relating to the consumer market section.

Approximately how much money the people of a given section maintain in the bank, what proportion of them file income tax returns, how many automobiles they own, the number of wholesale and retail outlets that serve them—are a few of the fundamental factors entering into an appraisal of marketing possibilities which this new supplement brings together. Population, both city and rural, is shown for each county in the country as of the 1930 census count. Value of manufactured products, value added by manufacture, and worth of mine output, are reported on the basis of 1929 returns. Savings, deposits, postal receipts, and users of telephones, also are reported in terms of counties.

A large number of other tables and maps

## Two Electric Locomotives Shipped to U.S.S.R.



TWO complete electric locomotives, the first of eight for service on the Transcaucasian Railway in the U.S.S.R., have just been shipped from the Erie (Pa.) Works of the General Electric Company. Weighing 145 tons each, these two locomotives required six flat cars to transport them from the factory to New York, whence they were sent by ship to the Port of Batum through the Mediterranean Sea. The Transcaucasian Railway is part of the government owned system of the U.S.S.R.; it extends through the Suram Pass, the electrified section being about 40 miles in length, and including heavy grades. The locomotives, intended for both freight and passenger service, are of the six-axle type, and will be capable of being coupled together to form units of 290 tons and 5,400 hp., among the most powerful in Europe. Regenerative braking is provided. Tests on the locomotives are expected to be carried out during June, with complete electrical operation of the mountain section scheduled to begin in October of this year.

is given, some of these indicating the changes which have taken place since publication of similar data.

The "General Consumer Market Statistics" is published as part of a general program for providing American business with basic information which will enable the individual concern to increase the efficiency of its sales and marketing methods, and thus help to reduce wastes in the national distribution system. This publication may be purchased at 60 cents per copy from the Superintendent of Documents, Government Printing Office, Washington, D. C., or any of the district offices of the bureau located in principal cities. Copies of the third printing of "The Market Data Handbook" are available at $2.50 per copy.

# Letters to the Editor

## The Forces of Ignorance

*To the Editor:*

I have frequently in the past few months seen references to "the forces of ignorance, tradition" and so on, in various ELECTRICAL ENGINEERING articles; and now again in the March issue in Doctor E. W. Rice's address, as recorded on page 197, we have—"The forces of ignorance, tradition, and superstitition are strong and view with some alarm the progress of science" . . . "After all, the forces of reaction and ignorance cannot prevail permanently in a country in which the voters are properly educated."

Now, I for one of the readers of ELECTRICAL ENGINEERING would like to know just what these "ignorant, superstitious forces" are. Enough of this vague generalizing; if such forces exist let's have them named and combat them like intelligent beings, if they should be combated.

Yours truly,

FRANCIS L. BURKE (A'28)
(Mfg. Planning Engr., Western Elec. Co., Kearney, N. J.)

## Has Man Benefited by Engineering Progress?

*To the Editor:*

Through engineering progress man has revolutionized transportation and communication. He has harnessed the forces of nature and commands them do his bidding. He has appropriated for his use and entertainment all the marvelous inventions, developments, and improvements in the electrical, mechanical, chemical, and civil arts and sciences. Through engineering progress man has lightened his labors, increased his hours of leisure, expanded his means of entertainment, and increased his vision. But has man benefited by engineering progress?

This question cannot be answered affirmatively by merely enumerating the tremendous increase in economic wealth brought about by engineering progress. It is first necessary to come to an understanding of the significance of the word "benefited," the definition of the word being of but little assistance. The implication of the word "benefited" in any particular case is quite clear: a patient is benefited by the medical ministration that relieves his pain or restores his health, a sorely fatigued person is benefited by rest, a hungry person by food, the lonesome by companionship. But the patient aggravated by the best of potions, the man forced into idleness by unemployment, the farmer glutted with a surplus of food, the socially-lionized surfeited with companionship, certainly are not benefited. The objective, the result sought, as compared to that obtained, becomes a measure of the beneficialness of a man's acquisitions; it must result in a want satisfied.

Engineering progress is conceded by all to be the most powerful influence in the life of modern man. His work, his travel, his amusement, and his rest; his life and his health; his political, his social, and his home life, have all been affected or better still revolutionized. How can the benefit of such a deep and wide spread influence be measured? It can be done by finding man's objective, man's primary want and then inquiring as to what extent engineering progress satisfied that want. This primary want is, without question, happiness. Whatever man does, he does so because he thinks or believes that it will enhance his happiness. Even if his actions be entirely altruistic there is no denying the fact that he gains a measure of personal satisfaction from that act.

In the light of this primary want, has man benefited by engineering progress? The answer is that he has benefited but little, if at all. There are no available statistics to verify the truth or falsity of this statement. It is, however, easily observed that the greater happiness prevailing at the crest of a business cycle due to the higher standard of living made possible by engineering progress, is matched by an equal amount of misery at the trough of the same cycle; the latter seems to be in direct proportion to the former.

The man who has owned an automobile is as miserable when he can no longer afford the luxury, as the man who is compelled to move to a less pretentious apartment. It is the stepping down from an accustomed standard that brings on the state of unhappiness and not the particular height of the standard. This is attested to by the many visitors to our shores coming from less industralized countries. Each one would consider our present standard a godsend for his nationals. Several months ago an Englishman, upon leaving our shores, said that England would be a happy land if it were afflicted with the American depression. It is evident, therefore, that it is not the absolute status of the standard but the drop of same that hurts. Happiness during the rise is, therefore, offset by the unhappiness during the drop, leaving but a small sum total of benefit from engineering progress.

Engineering progress has been sporadically raising that standard; but the engineering profession, I regret to say, has made no attempt to so plan the progress as to make the rise smooth and uniform. Engineers have contributed all of the technical progress of mankind but have left to others the management or rather mismanagement of their contributions. Even to the present day many engineers look askance at the political and social activities of the professional engineering associations.

The engineer, accustomed to long-range planning, familiar with the industrial machine he has built, peculiarly trained for the job, should take a greater hand in the management of affairs. The national engineering societies could help much in bringing the engineer out of his purely technical shell. Assuming a little responsibility in investigating conditions, and the causes for same, and doing some planning for the future, and giving properly worked out plans suitable publicity, will certainly not hurt the engineering profession. In due time it may perhaps definitely be said that man is benefiting by engineering progress.

Yours very truly,

JACOB KATZMAN (A'20)
(Consulting Engr., Dumont Elec. Co., New York, N. Y.)

## Injuries From Electric Shock

*To the Editor:*

Referring to letters upon the general subject of vivisection that you have recently published, permit me a suggestion.

To alleviate the suffering of human beings we must have knowledge of a type that can be obtained only by experiment upon living organisms. The organisms may be either human or animal. When a human organism objects to the use of animal organisms for the benefit of himself and other human organisms, I think that it would be entirely proper for him to offer himself as a subject for the necessary experiments. Surely the objector will be willing to display in so practical a manner the humanitarianism that he has expressed with such feeling on paper.

I commend this suggestion to the attention of all those who would rather see a thousand children suffer than to have one of the lower animals put out of the way, under proper safeguards, to save the kids.

Very truly yours,

H. H. KETCHAM (A'13, M'23, Life Member) (Technical Editor, Forest Products Lab., Madison, Wis.)

## Injuries From Electric Shock

*To the Editor:*

I was very much interested in the articles by Dr. Kouvenhoven and others discussing the nature of injuries from electric shocks. All the utility engineers who have had occasion to testify in lawsuits involving personal injury, or who have heard the medical profession testify in such suits realize the lack of available information at the present time.

We are hopeful that experimental work will be continued and that the results will be made available to the electrical profession, as in the past.

Yours very truly,

E. E. GEORGE (A'20, M'29)
(Supt. of Electrical Operation, Tennessee Elec. Pwr. Co., Chattanooga, Tenn.)

# American Engineering Council

## Public Works Administration

The possibility of securing a public works administration during this session of Congress was greatly enhanced by the action of the House of Representatives on the omnibus economy bill. A special rule was obtained making the bill a part of the legislative appropriation bill, which will insure action upon its provisions by the Senate during this session of Congress. Title V of the bill authorizes the formation of the public works administration under an administrator who shall hold office for six years, and receive a salary of $10,000 per year. In its present form the bill provides that the rivers and harbors activities of the War Department be excluded from this administration. In passage through the house, but two minor perfecting amendments were made to this section, the effect of which was to make the provision applicable only to the officers of the corps of engineers and not to enlisted or civil service personnel.

The A.E.C. has sponsored several amendments to Title V of the bill to the effect that:

1. The term of office of the administrator of public works be extended to at least ten years.
2. Inasmuch as the administrator will deal with highly technical questions, definite stipulations as to his qualifications should be included in the bill.
3. Rivers and harbors work of the War Department should be under the administrator of public works.
4. The administrator of public works *may* (not *shall*) utilize the services of the corps of engineers of both the United States Army and Navy whenever and wherever practicable.
5. The administrator of public works be given authority to employ as special consultants, experts without civil service status.

The bill is now before the Senate where it is certain to receive some action within the near future. It seems highly probable that the Senate either will amend Title V or strike the entire section from the bill. Should this latter action take place, the president would have ample opportunity under another provision of the bill to group and consolidate into one given department all of the executive agencies having to do with public works construction.

**Muscle Shoals Bill Passed by House.**—On May 5, 1932, the House of Representatives passed the Muscle Shoals bill (HR11051). In many respects this bill is similar to the one vetoed by President Hoover last year, providing that the government may lease Muscle Shoals properties under certain conditions; in the event of its inability to lease the properties before a given time, the bill provides that they may be operated by the government.

**A.E.C. Gets New Member.**—The Society for the Promotion of Engineering Education recently became a member-organization of the American Engineering Council. This is regarded as an extremely important step in the development of the council inasmuch as the S.P.E.E. is the foremost exponent of engineering education in the United States.

# Personal

Adolph Shipek (A'23, M'29) design engineer for the Puget Sound Power and Light Company, Seattle, Wash., has been awarded the A.I.E.E. North West District 1931 prize for best paper. Mr. Shipek, a native of the State of Wisconsin, received his preliminary schooling at Antigo, and in 1909 was graduated from the electrical engineering course at the University of Wisconsin, Madison. Upon completion of his college course, he became a student apprentice with the Allis-Chalmers Company. During the following year he was engaged in construction work on the White River hydroelectric plant of the Puget Sound Power and Light Company, Seattle, Wash., and in 1911 he became draftsman on electrical substation installation for that company, continuing in this capacity for a period of four years. In 1918 he became chief electrician for the Norway Pacific Construction and Dry Dock Company at Everett, Wash. Two years later he was chosen mechanical and electrical draftsman for the Seattle School District, and was employed by the City of Seattle on its Skagit hydroelectric development. In 1921 he again became affiliated with the Puget Sound Power and Light Company, was made field engineer of that company in 1924, and later design engineer, the position he now holds.

ADOLPH SHIPEK

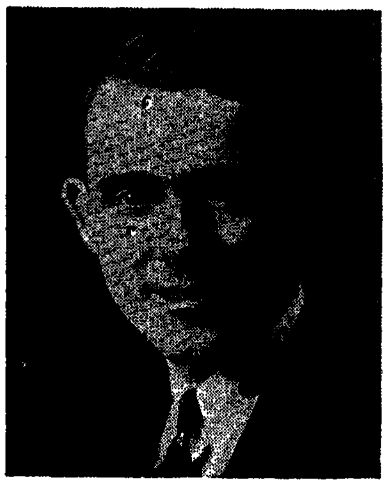
Gerard Swope (A'99, F'22) president of the General Electric Company, Schenectady, N. Y., has received the Gold Medal award of the National Institute of Social Sciences, "in recognition of his public service in formulating the Swope plan for the stabilization of industry with a guarantee of employment." The address of presentation was made by Owen D. Young, at the organization's annual dinner at the Waldorf-Astoria Hotel, New York, N. Y. In his speech of acceptance Mr. Swope expressed a satisfaction with the country's courageous attitude during the past two years. "Our primary thought for today," he asserted, "is how to emerge from these trying and difficult times as rapidly and as equitably as possible... If we are to maintain confidence, which is so absolutely essential, a definite program should be adopted toward balancing the budget of each of the various units in our country."

J. L. Watson (A'17) station meter tester for the Portland (Ore.) General Electric Company, has received the 1931 A.I.E.E. North West District prize for initial paper. Mr. Watson was born at Warren, Ohio, completed grade school and two years of high school at Meadville, Pa., then moved to Oregon and finished his high school course at Eugene. This was followed by a four-year course in electrical engineering at the University of Oregon (Eugene) from which he was graduated in 1915. After this he spent one term on a special course at Cornell University, Ithaca, N. Y., and a year on the General Electric test course at Pittsfield, Mass. At various times during his college years, Mr. Watson was employed as operator for the City of Eugene water works, for the Oregon Power Company at Eugene, and for the North Coast Power Company at Vancouver, B. C. He became affiliated with the Portland General Electric Company in 1920 and has been in the employ of that company since that time. He has taken a keen interest in Institute affairs and has served on many committees of the Portland Section.

J. L. WATSON

J. B. Whitehead (A'00, F'12) dean of the School of Engineering, Johns Hopkins University, and a member of its faculty since its organization, has been honored twice recently. He has been elected to membership in the National Academy of Sciences, the total membership of which is restricted to approximately 150 persons; and he has been awarded the Franklin Institute's Elliott Cresson Gold Medal and certificate for his work in dielectrics. The Elliott Cresson award was established in 1848 and is given "for discovery or original research, adding to the sum of human knowledge irrespective of commercial value;

leading to practical utilization of discovery; and invention, methods of products embodying substantial elements of leadership in their respective classes, or unusual skill or perfection in workmanship." The first award of this medal was made in 1856.



E. A. CHURCH

E. A. Church (A'29) who is now in the electrical engineering division of the Edison Electric Illuminating Company of Boston, Mass., was elected to receive the 1931 A.I.E.E. North Eastern District prize for initial paper. Mr. Church is a native of Franklin Grove, Ill. He was graduated from a cooperative course at Massachusetts Institute of Technology with the degree of S.M. in E.E. in June 1928. During his graduate year at M.I.T., Mr. Church was Swope Fellow in electrical engineering. He has been engaged with his present company ever since graduation, his work including various substation, transmission, and generation problems in connection with power system operation.

P. H. Moon (A'24, M'29) assistant professor in the electrical engineering department of Massachusetts Institute of Technology, Cambridge, Mass., has received the 1931 A.I.E.E. North Eastern District prize for best paper. A native of Beaver Dam, Wis., Mr. Moon was graduated from the University of Wisconsin in 1922 with the degree of B.S. in E.E. He was for a short while laboratory assistant for the Public Service Company of Northern Illinois at Joliet, Ill. After two years in the electrical and mechanical design schools of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., he joined the staff of M.I.T. in 1924 as research assistant. He has made several contributions to A.I.E.E. literature.

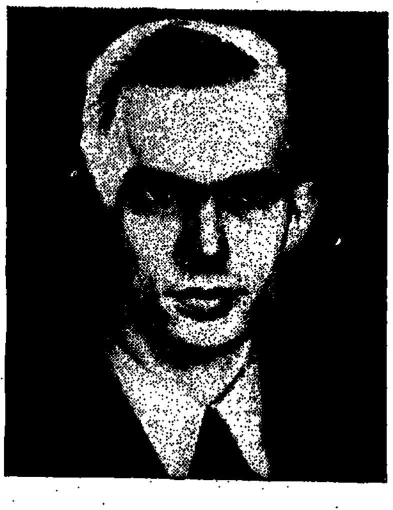
R. W. Alexander (A'28, M'30) formerly with Allied Engineers, Incorporated, and later with the Consumers Power Company, both of Jackson, Mich., has resigned his position with the latter company to join the Anaconda Wire and Cable Company, New York, N. Y. While with Allied Engineers, Incorporated, Mr. Alexander was connected with system planning. He has served on the power systems engineering committee of the National Electric Light Association.

M. Luckiesh (A'11, M'15) director of the General Electric Company lighting research laboratory at Nela Park, Cleveland, Ohio, recently received appointment to represent the United States National Committee on the technical committee on ultraviolet radiation of the International Commission on Illumination. The purpose of this committee is to define units and methods of measurement and for the appraisal of ultra-violet radiation.

F. D. Webber (A'09, M'30) who has been serving the Oregon Insurance Rating Bureau at Portland, Ore., as chief electrical engineer, recently was elected president of the International Association of Electrical Inspectors, the headquarters of which are in Chicago, Ill.; he is also secretary-treasurer of the Northwestern Section of this same organization. In his office as president he succeeds R. H. Manahan (M'22) of Los Angeles.

Richard McKay (A'22) assistant electrical engineer for the Washington Water Power Company, Spokane, Wash., has been appointed district manager of that company's Coeur d'Alene, Idaho, operations, which includes both electric and water service. His affiliation with this company dates from 1921, following his graduation from Columbia University, New York, N. Y. Mr. McKay is also chairman of the Associated Engineers of Spokane.

D. C. Robinson (A'32) who is at present a graduate assistant at the College of Applied Science, Syracuse University, Syracuse, N. Y., recently in his joint authorship with R. W. Stone, was voted the 1931 prize for Branch paper in the Institute's North Eastern District. Mr. Robinson, a native of Newell, Iowa, entered Syracuse University as a student in the electrical engineering department in 1927 and received his B.S. in E.E. in 1931. In the fall of 1931, he engaged with the General Electric Company to begin work in its vacuum tube research laboratory at Schenectady, October 1932. He now is working for his M.S. in E.E., his major teaching subject at the College of Applied Science being descriptive geometry. During the period from September 1930 to June 1931, he was chairman of the A.I.E.E. Branch at Syracuse University and also was chairman of the North Eastern District meeting Student session at Rochester, N. Y., May 1, 1931.



D. C. ROBINSON

Guglielmo Marconi (HM'17) recently was the recipient of the 1932 Kelvin Medal, which is awarded triennially by the Institution of Civil Engineers of Great Britain. The Kelvin Gold Medal, being a tribute of engineers to the memory of Lord Kelvin, is awarded to men of distinguished service in the application of science to engineering rather than in the development of physical science itself. The first award was made in 1920.

Frank Wenner (A'12, F'26) physicist, Bureau of Standards, Washington, D. C., recently was awarded the John Price Wetherill Medal, which The Franklin Institute presents annually "for discovery, invention, or development in the physical sciences." This medal award was established in 1925, for the promotion of research.

W. S. Watson (A'28) for many years chief engineer and manager of the city water and light supply for Hastings, Neb., recently received his appointment as superintendent of the board of public works at Hannibal, Mo. In this office he will be in charge of the Hannibal municipal supply of water, light, and power.

C. E. Allen (A'04, F'14) who for some time served the Westinghouse Electric and Manufacturing Company as its southwest district manager, with offices at St. Louis, Mo., and who is at present its commercial vice-president at East Pittsburgh, Pa., recently was elected vice-president of the American Management Association.

F. J. Bartlewski (A'28) who has been serving the International General Electric Company at Bucharest I., Roumania, now has been transferred by his company to Bombay, India. Prior to his work in Bucharest, Mr. Bartlewski was X-ray engineer for the General Electric X-Ray Corporation at Warsaw, Poland.

G. E. Wood (A'26) for some time a member of the firm of Langner, Parry, Card, and Langner, patent attorneys in New York, N. Y., has located in Dublin, Ireland, as assistant patent agent for Cruickshank and Company, an organization which has been operating for over thirty years and closely allied with Mr. Wood's previous connection.

E. W. Davis (A'15, M'21) has been made electrical engineer for the Simplex Wire and Cable Company, Cambridge, Mass. He succeeds W. I. Middleton (A'09, M'14) who was forced to retire a short time ago because of ill health. Mr. Davis' previous office with the company was that of assistant electrical engineer.

J. C. Parker (A'04, F'12) was recently appointed to the board of directors of the American Standards Association, to succeed M. S. Sloan (A'07, F'30) whose term expired December 1931. Mr. Parker represents the electric light and power group on that board.

**R. B. May** (A'12) for several years has been vice-president and assistant managing director of the Overseas Motor Service Corporation, New York, N. Y.; now he has removed to Chicago to become curator of automotive engineering at the Museum of Science and Industry in that city.

**H. W. Fisher** (A'95, F'12) who is a Member for Life of the Institute and who for some time has been consulting engineer for the General Cable Corporation, located at Perth Amboy, N. J., now has retired from active service. His future address will be Laguna Beach, Calif.

**W. J. Berry** (A'31) is now assistant equipment supervisor of the Southeast Missouri Telephone Company, and is located at Cape Girardeau, Mo. As a student engineer of the General Electric Company, Mr. Berry was located previously at Lawrence Park, Erie, Pa.

**C. O. von Dannenberg** (A'06, M'30) who formerly was assistant electrical engineer of the Electric Management and Engineering Corporation, New York, N. Y., recently became a member of the engineering department of the Pennsylvania Central Light and Power Company, Altoona, Pa.

**C. M. Gilt** (A'21, M'26) outside plant engineer for the Brooklyn Edison Company, Brooklyn, N. Y., has received the appointment of assistant electrical engineer of that company. Mr. Gilt's first connection with the Brooklyn Edison Company was as test engineer in 1923.

**V. M. Graham** (A'23, M'29) radio engineer for the Stromberg-Carlson Telephone Manufacturing Company, at Rochester, N. Y., recently was appointed chairman of the standards section of the Radio Manufacturers Association of New York, N. Y.

**Edward Allen** (A'30) field engineer for the Public Service Company of Northern Illinois, has been transferred from the Maywood (Ill.) territory to Harvey, Ill., were he will continue in the capacity of field engineer.

**William Arthur** (A'12, M'17) previously located in New York, N. Y., as assistant to vice-president, American Brown Boveri Company, now should be addressed in care of Allis-Chalmers Manufacturing Company, New York, N. Y.

**W. H. Harrison** (A'20, M'30) plant engineer for the American Telegraph and Telephone Company, New York, N. Y., at a recent election was chosen to serve on the executive committee of the A.I.E.E. New York Section.

**F. A. Lavigne** (A'26) who for many years has been local manager of the Associated Wholesale Electric Company at Los Angeles, Calif., now has associated himself with The Electric Material Company, Inc., of San Francisco.

**S. A. Smith, Jr.** (A'24) assistant transmission engineer for the Public Service Electric and Gas Company, Newark, New Jersey, has been made chairman of the power group of the Institute's New York Section for 1932–1933.

**I. S. Coggeshall** (A'30) general traffic supervisor of the Western Union Telegraph Company, New York, N. Y., recently was elected to the chairmanship of the communication group of the Institute's New York Section for 1932–1933.

**W. T. Blackwell** (A'22) general lighting representative of the Public Service Electric and Gas Company, Newark, N. J., has received reelection as chairman of the illumination group of the Institute's New York Section for 1932–1933.

**H. C. Dean** (A'12, F'30) general superintendent of the New York and Queens Electric Light and Power Company, Flushing, N. Y., has been elected to serve for 1932–1933 on the executive committee of the Institute's New York Section.

**J. D. Carroll** (A'21) formerly assistant engineer of the Electric Bond and Share Company, New York, N. Y., now is serving the Public Service Commission of Maryland, at Baltimore, in like capacity.

**R. W. Stone** (A'32) of the sales department of the Oswego Motor Car Company, Oswego, N. Y., shares with **D. C. Robinson** (A'32) the North Eastern District prize for the Branch paper for 1931. Oswego is Mr. Stone's native city. He received his B.S. in E.E. from Syracuse University with the class of 1931, and the summer between his junior and senior years worked for the American Telephone and Telegraph Company, New York, N. Y., in the transmission engineering department, where his work consisted chiefly of becoming acquainted with the various phases of telephone work in connection with carrier telephone systems and central offices, radio program transmission, and telephone plant maintenance.

R. W. STONE

**J. R. Batcheller** (Enrolled Student) Oregon State Agricultural College at Corvallis, Ore., has been awarded the Institute's North West District prize for Branch paper presented during 1931. The award was made for Mr. Batcheller's paper, "Abridged Method of Testing Welds," presented at a joint meeting of the Oregon State College Branch and the A.I.E.E. Portland, Ore., Section, May 23, 1931. The author is a native of Portland and is continuing his studies at the Oregon State college, where he took a course in electrical engineering and from which he was graduated in 1931 with his B.S. degree.

J. R. BATCHELLER

**G. R. Dittwe** (A'26) until recently sales engineer for the Garland-Affolter Engineering Corporation at Los Angeles, Calif., is now manager of Electric Agencies at Oakland, Calif.

**J. E. Woods** ('30) assistant chief engineer of the Central Power and Light Company, San Antonio, Texas, as of April 14, 1932, was transferred to Guero, Texas, where he continues to serve the company.

**C. O. Evans** (A'22) who has been serving the British American Metals Company of New York, N. Y., as secretary, now is secretary of the British-American Tube Company, New York, N. Y.

**W. P. Hammond** (M'20) formerly engineer of generating plants, Allied Engineers, Incorporated, Birmingham, Ala., now has become general engineer of the Georgia Power Company at Atlanta, Ga.

**T. F. Barton** (A'12, F'30) district engineer for the General Electric Company, New York, N. Y., is the new chairman of the New York Section of the Institute, to hold office during the fiscal year 1932–1933.

**W. R. Smith** (M'18, F'30) assistant chief engineer, United Engineers and Constructors, Inc., Newark, N. J., has been elected secretary of the Institute's New York Section for 1932–1933.

**L. L. Edgar** (A'12) vice-president in charge of the operating bureau of the Edison Electric Illuminating Company of

Boston has succeeded his father in the office of regional director for New England of the refrigeration bureau of the National Electric Light Association.

# Obituary

**Benson Osborn Ellis** (M'23) operating manager of the Cia Anglo Argentina de Electricidad, S. A., died there of cerebral hemorrhage, October 1931, according to information received recently. He was born in Corina, Maine, September 24, 1873, and was a graduate of the high school at Dexter, Maine. In 1890 he engaged with the Brunswick Electric Light and Power Company, Brunswick, Maine, as station operator, having worked previously on inside wiring and line construction. Three years later he joined the Knox Gas and Electric Company and the Rockland, Thomaston and Camden Street Railway Company, Rockland, Maine, as construction foreman in charge of overhead work, inside wiring, customers' installations, and also operation of the power plant. In this position he remained for four years, after which he went to Astoria, N. Y., in 1897, where he became electrical superintendent in charge of power plant operation, overhead line construction, and customers' installations for the Astoria Electric Light and Power Company. Later he was associated with William Sheehan and Company, contracting engineers, New York City, in charge of the design and construction of small central station installations. In 1906 he became construction superintendent of the J. G. White & Company, Inc., taking over the general charge of new power plant and substation construction, high voltage transmission, and street railway extensions and repair for the Eastern Pennsylvania Railway Company, Pottsville, Pa. His next change came in 1908 when he went with the Columbia Power, Light and Railways Company as general manager in charge of rehabilitation and operation of street railway, and gas and electric light properties, in Berwick, Bloomsburg, and Danville, Pa. In 1910 he returned to the J. G. White organization and was active on many important projects. He was placed in charge of powerhouse extension, substation, and underground work and the rebuilding of street railway lines for the Wilmington and Philadelphia Traction Company, Wilmington, Del.; in 1912 he was sent to take charge of powerhouse and substation construction, transmission line erection, and low voltage distribution for an electric company in Venezuela; and in 1914 he was sent to take charge of the building of the street railway system for the Quito Tramways Company, Quito-Ecuador, S. A. The last named connection led to his appointment as general manager and chief engineer of the Quito Tramways Company and the Quito Electric Light and Power Company. In 1923 he returned to the United States and established an electrical engineering and construction business of his own in New York City. In this he continued until he went to Cuba to take charge of electrical engineering and construction for the Cuban Electric Company at Havana. The year 1927 found him division manager of the Florida Power and Light Company, at Sarasota, Fla., the position which he left when he was made assistant to the president of the Public Utilities Consolidated Corporation, at Minneapolis, Minn., in 1929. Immediately prior to his last position in Argentina, he was president of the Central American Power Corporation at Nicaragua.

**Henry E. McGowan** (M'17), secretary of the Brooklyn (N. Y.) Union Gas Company, died at the Long Island College Hospital, Brooklyn, N. Y., May 7, 1932. He had been with that company for 24 years. Mr. McGowan was a native of Brooklyn; his early education was obtained at private schools and included five years of military training. In 1889 he went to the Stevens Institute preparatory school and in 1894 was graduated from Stevens Institute with a degree in mechanical engineering. For the next three years he was process chemist for Church and Company, Trenton, Mich., a concern manufacturing soda by a special ammonia process. In this connection, Mr. McGowan first served a term in the company's laboratory immediately under the chief chemist and in complete charge of process of production. In 1898 he went with the Brooklyn Union Gas Company as electrical engineer, his chief duties being to investigate the matter of electrolytic damage to sub-surface plant, and to follow up prospects for gas-engine-driven electric installations. In addition to these duties, in 1903 he was elected general manager of the Flatbush Gas Company. This company was a subsidiary of the Brooklyn Union Gas Company, but carried on an electric power business in addition to its gas distribution activities. In this affiliation all extensions of electric station and distribution equipment were carried out directly under Mr. McGowan's supervision and direction, including the purchasing of all turbo-generators, boilers, condensers, and other necessary equipment, and the prescribing of the systems and designs to be employed. In 1914 he was made assistant secretary of the Brooklyn Union Gas Company, at the same time holding like office in five of its subsidiaries, and in addition retaining the title of general manager at the Flatbush Gas Company. Mr. McGowan has contributed two articles to technical literature: "Electrolysis, the Effect of Stray Trolley Currents," published in the *Stevens Indicator*, and a "Remedy for Electrolytic Damage to Mains," published in *Progressive Age*. He was a member of the National Electric Light Association, the Brooklyn Chamber of Commerce, the American Gas Association, and The American Society of Mechanical Engineers. He held membership also in the Crescent Athletic-Hamilton Club.

**Carl Leo Mees** (A'03) president emeritus of Rose Polytechnic Institute, Terre Haute, Ind., and prominent as a scientist and medical authority, died at Terre Haute, April 19, 1932. He was born at Columbus, Ohio, May 20, 1853, and in due course of time became a student at Ohio State University. This schooling was amplified by a course at the University of Berlin, Germany, with study under the eminent physicists, Hermann Helmholtz and Gustav Kirchhoff. In further pursuit of knowledge, he went to South Kensington, England; then, returning to the United States and his native city, he entered the Starling Medical College at Columbus, Ohio, but never practised medicine. In 1871 as chief chemist he was with the Ohio geological survey and state gas commission, and four years later became professor of physics and chemistry at the University of Louisville, Ky. From 1881 to 1887 he was professor of chemistry and physics of the newly organized Ohio University at Athens, Ohio, later in 1887 assuming his professorship at Rose Polytechnic Institute as teacher of physics and electricity. His presidency there extended over the period from 1895 to 1919, when he resigned the active presidency and became president emeritus. Perhaps the best known of Doctor Mees's achievements was the development of a process making possible microscopic photographs of human blood and minute tissues. This process was adopted by the Army and Navy research departments, and was employed nationally in the detection and solution of crime. He was a Fellow of the American Association for the Advancement of Science, of which he was also general secretary in 1889 and a vice-president in 1896; his other memberships included the American Physical Society, the Society for the Promotion of Engineering Education, and the Indiana Academy of Science. He was also an honorary member of the State Credit Men's Association. Doctor Mees was the author of many scientific papers and contributions to technical literature.

**Harry N. Van Deusen** (A'19, M'30), materials engineer for the Bell Telephone Laboratories, Inc., New York, N. Y., died suddenly May 15, 1932, at the Easton Hospital, Easton, Pa. He was born at Columbia, N. J., December 3, 1884, and was graduated from Purdue University, Lafayette, Ind., in 1907 with the degree of B.S. in E.E. In June 1907 he engaged with the maintenance department of the Chicago Telephone Company (Ill.), where he gained a varied experience in central office testing, outside testing and installation, and inspection of central office equipment. March 1909 he returned to the University of Purdue as professor of machine design, remaining in this teaching capacity until the end of the school term. He then became equipment engineer of the Western Electric Company, at Hawthorne, Ill., and continued there until 1912, when he was transferred to the engineering department of the Company in New York. In 1925 he became a member of the technical staff of the Bell Telephone Laboratories, Inc., and was at the time of his death one of its workers in the analytical study of magnetic materials, insulating materials, protection apparatus and the analysis and testing of all types of telephone apparatus. A resident of East Orange, N. J., for the past twenty years, he was chairman of the insulating materials committee of the American Society for Testing Materials, a member of the New York Electrical Society, and was the Bell Telephone Laboratories' representative in the American Welding Society.

**William H. Hill** (A'04) superintendent of electrical construction for the New York Edison Company, and an employee of that company for 42 years, died May 4, 1932, after a short illness. He was 66 years of age. Born in Philadelphia, Pa., Mr. Hill started his electrical career, in 1888, as a splicer's helper with the Philadelphia Edision Company. Approximately ten years later he became a splicer for the Toronto Edison Company. The following year he returned to the United States and engaged with the New York Edison Company, then the Edison Electric Illuminating Company, still as a splicer of cables. From then on his promotion was rapid; in 1902 he was made foreman, a year later being advanced to general foreman, the next year to assistant superintendent of electrical construction, and shortly thereafter to the office he last held, superintendent of electrical construction. His effort with the New York Edison Company was not restricted to purely departmental activities, for it was through his instrumentality that the Edison Company's Employees' Association was founded, Mr. Hill being placed in the presidency of that organization. He was a member of the Edison Pioneers.

**Louis George Freeman** (A'16) for more than twenty years in charge of the lighting, power, and signal systems, and the design and installation of simple laboratory apparatus for the U. S. Geological Survey, Washington, D. C., died December 8, 1931, according to word recently forwarded to Institute headquarters. Mr. Freeman was born at Washington, D. C., January 27, 1869, and after public schooling, spent three years at George Washington University, Washington, D. C.

# Local Meetings

## Student Convention Held in New York

A highly successful student convention was held on April 29, 1932, at Institute headquarters by the several Branches within the territory of the Institute's New York Section. Eight Branches participated as follows: Brooklyn Polytechnic Institute, Cooper Union, Newark College of Engineering, College of the City of New York, New York University, Pratt Institute, Rutgers University, and Stevens Institute of Technology.

The morning session was devoted to inspection trips to various nearby points of interest. During the afternoon session, a talk on "Photofilms" was given by Dr. Johnson O'Connor (A'22) of Stevens Institute, after which a dinner was held at the Hotel McAlpin. A joint student meeting and general Section meeting was held during the evening.

The first portion of the evening program was devoted to the presentation of three student papers entered in competition for the New York Section student-paper prizes. The first prize of $25 went to Russell Buehl of Brooklyn Polytechnic Institute for his paper "Frequency Control by Means of the Thyratron Tube"; second prize of $10 to E. Olsta of Newark College of Engineering, for his paper "Carrier Current Communication as a Factor in the Stability of Power Systems." The awards were made by a group of prominent New York Section engineers.

During the second portion of the evening session, Dr. Frank B. Jewett (F'12 and past-president), vice-president, American Telephone and Telegraph Company, New York, gave a talk on "What the World Expects of the Electrical Engineer." "Graduates of the present period," said Doctor Jewett, "do not find before them the rosy outlook enjoyed by graduates of a few of the preceding years. Nevertheless on the basis of my own life-work I believe that a hard path at the start of a professional career is of tremendous value as a character builder and developer of the best traits."

Later in his address Doctor Jewett declared: "The past 50 years' work has been *creative;* now we have entered into a period which has an objective slightly different from that of the period just passed. There have been so many developments, and they have been prosecuted so individually that now more than ever the problem of coordination looms up as of prime importance not only within the technical field of the electrical engineer, but also in the relation of that field to every-day life. Coordination inevitably will be the, or one of the, most compelling problems challenging the electrical engineer in the future."

### Method of Judging Student Papers

Because of the success of the method used by the committee in judging the papers, a brief outline of this method is presented herewith in the belief that it may be of some value to other committees facing similar problems. Each Branch was allowed to submit one paper for the competition; the written papers then were rated independently by three judges on the basis of the following points:

| | |
|---|---|
| Grasp of subject | 10 points |
| Arrangement of material | 10 points |
| Constructive character of ideas | 10 points |

The three papers receiving the highest number of points in this first rating were selected for presentation at the convention, where the judges of the oral presentation rated them on the following basis:

| | |
|---|---|
| Clarity | 10 points |
| Force of expression | 10 points |
| General platform decorum | 10 points |

All Branches participating in the contest were informed in advance regarding details of the plan to be used; thus all contestants knew beforehand upon just what basis their papers would be judged. This common understanding, together with the fact that the judges were given definite points upon which to rate the papers are believed to be the two principal features contributing most toward the workability of the plan. The practicability and success of the system was demonstrated by the close agreement reached by the judges, all of whom worked individually.

## Schenectady and Pittsfield Sections Hold Competition

Following the plan inaugurated three years ago to encourage their younger members to participate in programs, the Schenectady and Pittsfield Sections held joint meetings in Schenectady, April 7, 1932, and Pittsfield, April 13, 1932, for the presentation of papers by section members less than 30 years of age, who had not previously presented Institute papers. The programs were as follows:

**Schenectady**

Protection of Underground Structures From Corrosion, by F. K. Fox, Pittsfield.
Calculation of Two Machine Stability With Resistance, by S. R. Pritchard, Schenectady.
The Blowing of Fuses by Impulse, by T. Brownlee, Pittsfield.
Increasing Stability Limit of Generators, by S. B. Crary, Schenectady.
Electrical Music, by A. H. Foley, Pittsfield.
X-Ray and Cathode Ray Tubes in the Production of New Forms of Life, by C. P. Haskins, Schenectady.

**Pittsfield**

Voltage Drop Calculations for Long Transmission Lines, by R. N. Slinger, Schenectady.
Measurement of Current in Impulse Circuits With the Cathode Ray Oscillograph, by S. W. Zimmerman, Pittsfield.
Design of Type D Carrier Telephone Facilities, by S. E. Benson, Schenectady.
Lightning Investigation on Transmission Lines, by H. E. Pierce, Pittsfield.
Startling Starts and Stops—Unusual Synchronous Motor Performance, by C. E. Kilbourne, Schenectady.
Thyratron Commutated Motor, by G. E. Nonken, Pittsfield.

Prizes were awarded after consideration of the contents of the papers as well as the presentation. At the Schenectady meeting, C. P. Haskins of Schenectady received the first prize, and S. R. Pritchard of Schenectady received second prize. The attendance was 250.

At the Pittsfield meeting, C. E. Kilbourne of Schenectady received the first prize and R. V. Slinger of Schenectady received the second prize. The combined prize, the F. W. Peek, Jr., cup, went to the Schenectady Section who are permanent holders since they won it two out of three years. The attendance was 175.

# Future Section Meetings

**Detroit-Ann Arbor.** June 21—spring frolic.

**Louisville.** June 3—Outdoor recreation meeting. Annual election of officers.

**Vancouver.** June 6—Annual dinner.

# Past Section Meetings

**Akron**

Inspection trip to the Ohio Edison Company's East Akron substation. The Load Shifting Transformers at Salt Springs, by J. H. Foote and L. N. Gozinski. Feb. 9. Att. 45.

Electric Refrigeration and Air Conditioning, by W. M. Timmerman, Genl. Elec. Co. The Electrical Industry and Some Problems of the Institute, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. April 12.

**Atlanta**

C. H. Dolan, Eastern Air Transport, and C. R. Whittaker, vice-consul, Foochow, China, gave talks on the Sino-Japanese situation. Joint meeting with A.S.M.E. Sec. March 21. Att. 75.

**Baltimore**

Material Handling, by H. V. Schmidt; Electrical Distribution System, Point Breeze Works, by W. A. Halliday; Power House, Point Breeze Works, by E. F. George; all of the Western Elec. Co. Films—"New Voice Highways" and "Modern Knight." Joint meeting with A.S.M.E. Dinner. April 14. Att. 180.

**Boston**

A General Description of the Lackawanna Electrification, by E. L. Moreland, Jackson & Moreland. Film—"On the Pathways of Progress." April 21. Att. 105.

**Chicago**

Design and Operation of Overhead Lines in Relation to Continuity of Service, by F. E. Andrews, Pub. Serv. Co. of No. Ill. March 17. Att. 115.

Rates and Rate Making, by F. E. Kruesi, Middle West Utilities Co. April 14. Att. 95.

Development of the Use of Electricity in Steel Mills, by C. J. Smith, Ill. Steel Co. Election of officers: L. R. Mapes, chmn.; E. C. Williams, vice-chmn.; D. L. Smith, secy.-treas. Joint meeting with Western Soc. of Engrs. May 2. Att. 134.

**Cleveland**

Electric Refrigeration and Domestic Air Conditioning, by W. M. Timmerman, Genl. Elec. Co. Illus. April 21. Att. 56.

**Columbus**

A-C. Networks, by F. W. Marquette, Columbia Ry. Pwr. & Lt. Co. Jan. 8. Att. 36.

Recent Telephone Research and Its Application, by S. P. Grace, asst. vice-pres., Bell Tel. Labs., Inc. Joint meeting with the A.S.M.E., A.S.C.E., Engrs.' Club, and Electric League of Columbus. Jan. 22. Att. 3485.

George Washington, Engineer, Business Man, and Statesman, by C. T. Marshall, Chief Justice Supreme Court, State of Ohio. Joint meeting with A.S.C.E., A.S.M.E., Engrs.' Club, in cooperation with George Washington Bicentennial Committee. Feb. 26.

Electric Shock, by Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres. A.I.E.E. Joint meeting with Ohio State Univ. Branch. Dinner. April 22. Att. 44.

**Connecticut**

Moulded Plastics, by F. J. Groten, Genl. Elec. Co. Feb. 16. Att. 65.

**Dallas**

The Coordination of Line and Station Design for Lighting Surge Conditions, by A. O. Austin, Ohio Brass Co. April 11. Att. 81.

**Denver**

Rural Electrification, by C. A. Lory, Colorado Agri. Col. Dinner. April 15. Att. 70.

**Detroit-Ann Arbor**

Commercial Metering of Electric Energy, by A. S. Albright, Detroit Edison Co. April 19. Att. 150.

**Florida**

Business meeting in Jacksonville, April 14, during spring meeting of Florida Engg. Soc., April 14–16. Reports by secretary and chairmen of membership and student activities committees. Appointment of nominating committee. Joint dinner on evening of April 14 of Florida Engg. Soc., and A.S.C.E., A.S.M.E., and A.I.E.E. Sections and Branches, Att. 20.

**Fort Wayne**

Reactance in Transformer Design, by J. F. Eitman, Genl. Elec. Co.; Transformers With Peaked Secondary Voltage Wave, by O. Kiltie, Genl. Elec. Co. Demonstrations. April 14. Att. 40.

**Houston**

Coordination of Line and Station Design for Lighting Surge Conditions, by A. O. Austin, Ohio Insulator Co. April 15. Att. 28.

**Indianapolis-Lafayette**

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Dinner. March 31. Att. 95.

The Corpuscular Theory of Light, the Wave Theory of Matter, the New Physics, by Prof. C. T. Knipp, Univ. of Ill. Joint meeting with Purdue Univ. Branch. April 26. Att. 205.

**Ithaca**

High Spots in the Design of Steam Electric Power Plants, by I. E. Moultrop, vice-pres., A.I.E.E., Chief Engr., Edison Elec. Ill. Co. of Boston. March 9. Att. 50.

**Kansas City**

General Features of Telegraph Service as Used in the Bell Telephone System, by B. A. Kahn, Southwestern Bell Tel. Co. April 18. Att. 48.

Adventures in Science, by E. L. Manning, Genl. Elec. Co. Meeting held in cooperation with the engineering societies of Kansas City, under the auspices of the Electric and Radio Assn. April 21. Att. 875.

**Lehigh Valley**

Power System Operation, by G. M. Keenan, Pa.-N. J. 220 Kv. Interconnection. Inspection trip through the Metropolitan Edison Co. Nov. 13, 1931. Att. 124.

Electrical Power in the Anthracite Fields and Its Application to Coal Mining, by W. H. Lesser, Penn Anthracite Mining Co. Inspection trip through the new Locust Summit central breaker of the Phila. and Reading Coal & Iron Co. Dec. 11, 1931. Att. 122.

Primary Network Distribution Systems, by D. K. Blake, Genl. Elec. Co. Jan. 15. Att. 176.

Research—Industry's Health Insurance, by S. M. Kintner, Westinghouse Elec. & Mfg. Co. Joint meeting with the Engrs.' Club. March 18. Att. 122.

**Los Angeles**

Radio Interference, by Prof. J. K. McNeely, Calif. Inst. of Tech. Dinner. April 12. Att. 86.

**Louisville**

Fundamentals of Plane Construction and Flight, by A. W. Lee, Louisville Gas & Elec. Co. Inspection trip through the Bowman Field airport. April 15. Att. 450.

**Lynn**

What Are You Afraid of? by Dr. Charles Newcomb. Banquet. April 9. Att. 194.

**Madison**

Prospecting in Science, by M. W. Hanks, Hankscraft Co. Dinner. April 20. Att. 65.

**Memphis**

Dredging Operations From the Time of the Civil War Up to the Present Date, by Major H. S. Gladfelter. April 12. Att. 33.

**Mexico**

Thermodynamic Considerations on the Modern Steam Turbine, by G. A. Schulenburg, A. E. G. Co. Dinner. March 17. Att. 28.

J. Herandez Olmedo described the organization and systems used by the National Telegraphs. Illus. Dinner. April 14. Att. 31.

**Milwaukee**

Television, by Sam Snead, Univ. of Wis. Joint meeting with the Engrs. Soc. of Milwaukee. Dinner. March 23. Att. 450.

**Minnesota**

Demonstration and lecture by S. P. Grace, asst. vice-pres. Bell Tel. Labs., Inc. Joint meeting with the Univ. of Minn. Branch. April 14. Att. 5000.

**Montana**

Light and Illumination, by Prof. J. A. Thaler and Prof. F. C. Bowman, Mont. State Col. Joint meeting with Montana Soc. of Engrs. April 11. Att. 60.

**Nebraska**

Lighting and Its Relation to Electric Apparatus, by Dr. C. L. Fortescue, Westinghouse Elec. & Mfg. Co. Dinner. March 18. Att. 80.

**New York**

Recent Developments in Radio Broadcasting, by R. L. Davis, Westinghouse Elec. & Mfg. Co., and E. W. Wallace, Am. Tel. & Tel. Co. March 15. Att. 300.

Regulation of Power Flow Between Interconnected Systems, by H. L. Melvin, Elec. Bond & Share Co., and J. B. McClure, Genl. Elec. Co. April 15. Att. 325.

Electric Locomotives on the Pennsylvania, by J. V. B. Duer, Penn. R.R. April 19. Att. 425.

**Niagara Frontier**

Nominating committee meeting. March 28.

Surge Proof Power Transformers, by H. V. Putman, Westinghouse Elec. & Mfg. Co. Illus. Election of officers: F. S. Wahl, chmn.; J. F. Oehler, secy.-treas. Dinner. April 15. Att. 90.

**North Carolina**

Spring meeting opened with address of welcome by Mr. House, Univ. of No. Carolina. Valuation for Rate Making, by R. O. Self, No. Carolina Corp. Comm.; Arc Welding as Applied to Manufacturing Processes, Covering Both Machinery and Buildings, by C. I. MacGuffie, Genl. Elec. Co.; Surge Proof Distribution Transformers, by H. D. West, Westinghouse Elec. & Mfg. Co.; Illumination for the Future, by R. A. Palmer, Southern Pub. Utilities Co. Illus. Short talk by W. S. Lee, past-pres., A.I.E.E., pres. W. S. Lee Engg. Corp. Dinner. April 5. Att. 180.

**Oklahoma City**

Vertical Transportation, by R. W. Van Kirk, Genl. Elec. Co. Discussion. March 21. Att. 60.

The Coordination of Line and Station Design for Lightning Surge Conditions, by A. O. Austin, Ohio Insulator Co. Dinner. April 21. Att. 90.

Adventures in Science, by E. L. Manning, Genl. Elec. Co. Demonstrations. April 25. Att. 1430.

**Philadelphia**

The Engineer's Professional Status, by Dr. W. E. Wickenden, Case Sch. of Ap. Sc. March 14. Att. 210.

The Institute and the Electrical Industry—What of Their Future? by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co.; Public Interest in Science, by Fred F. Shedd, managing editor, *Phila. Evening Bulletin.* April 11. Att. 160.

**Pittsburgh**

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co.; How to Interest the Public in Engineering News, by Mark Shields, *Pittsburgh Sun-Telegraph;* Rambling With Reichhold, by Ralph Reichhold, Pittsburgh Press artist; Electrifying a Specialty, by Dr. Charles Wales. Joint meeting with the Engrs. Soc. of Western Penn., and Carnegie

Inst. of Tech., Univ. of Pittsburgh, and Univ. of West Virginia Branches. Jan. 12. Att. 340.

Pittsburgh's Contribution to Radio Development, by S. M. Kintner, Westinghouse Elec. & Mfg. Co. Joint meeting with Engr. Soc. of Western Penn., held in connection with the annual convention of the I.R.E. April 7. Att. 500.

### Pittsfield

The Science and Theory of Magnetism, by Dr. S. R. Williams, Amherst Col. E. G. Newton received a prize for presenting the best paper before the Section during 1931. Dinner. April 22. Att. 110.

### Portland

Surge-Proof Transformers, by A. W. Copley, Westinghouse Elec. & Mfg. Co., vice-pres. A.I.E.E. April 12. Att. 52.

### Providence

Communication Systems Which Compromise the International Tel. & Tel. Network, by A. A. Clokey, Intl. Tel. & Tel. Co. Demonstrations. April 20. Att. 200.

### Rochester

Program Service Systems, by A. E. Soderholm. Jan. 14. Att. 69.

How a Modern Radio Station Functions, by Wm. Fay, Stromberg-Carlson Mfg. Co. Joint meeting with the I.R.E. Feb. 11. Att. 319.

Modern Manual Telephone Practise, by Mr. Vincent and Mr. Gillespie, Rochester Tel. Corp. March 3. Att. 94.

Changes in Methods of Industrial Development as a Result of Industrial Research, by Dr. F. B. Jewett, vice-pres., Am. Tel. & Tel. Co., and pres. Bell Tel. Labs., Inc. Demonstrations by Mr. L. S. O'Roark, Bell Tel. Labs., Inc. March 28. Att. 400.

The Application of Engineering Principles to the Production of Artificial Fever, by Dr. Stafford L. Warren. Joint meeting with the I.R.E. April 7. Att. 133.

### St. Louis

Heating and Overload Protection of Polyphase Motors, by C. P. Potter, Wagner Elec. Corp. Election of officers: F. B. Wipperman, chmn.; Ralph Kelley, vice-chmn.; S. L. Hilyard, secy. April 20. Att. 85.

### San Antonio

The Coordination of Line and Station Design for Lightning Surge Conditions, by A. O. Austin, Ohio Insulator Co. Illus. Dinner. April 18. Att. 110.

### San Francisco

The Precise Electrical Measurement of Short-Time Intervals, by Wm. McLeod, Univ. of Calif.; Influence of Conductor Temperature on Corona Loss, by A. K. Nuttall, Stanford Univ.; The Application of the Inverted Vacuum Tube to the Measurement of Voltages, by L. W. Thorpe and R. Sheridan, Univ. of Santa Clara, Joint meeting with the Univ. of Calif., Stanford Univ., and Univ. of Santa Clara Branches. First prize of one year's dues in the Institute was awarded to L. W. Thorpe, Univ. of Santa Clara. April 15. Att. 48.

### Saskatchewan

Loop Systems in H. T. Transmission for Urban Districts, by N. W. Dubois, Dominion Elec. Pwr., Ltd., and E. W. Bull, supt. of light and power of Regina. Feb. 5. Att. 31.

Ladies' Night. April 22. Att. 52.

### Schenectady

Seven members of the staff of the Genl. Elec. Co. spoke on the subject of noise measurement and reduction. Joint meeting with the A.S.M.E. Sec. March 3. Att. 225.

The Locomotives of the Future, by A. Lipetz, Am. Locomotive Co. Joint meeting with A.S.M.E. Sec. March 24. Att. 200.

### Seattle

Joint meeting with the Univ. of Wash. Branch, at which the following papers were presented by students: Measurement of Harmonics by Means of Vacuum Tubes, by R. M. Boyle; Magnetization Curve by Magnetic Pull Method, by M. Bouck; Velocity Aspects of the Electric Figures, by Arthur Kramer. April 19. Att. 80.

### Sharon

A Personal Tour of European Power Stations, by Philip Sporn, Am. Gas & Elec. Co. Film—"Behind the Lines." April 12. Att. 125.

### Springfield

The Earth, a Great Magnet, by Prof. S. Williams, Amherst Col. March 14. Att. 81.

Artificially Generated Sunlight, by Dr. Paul Luckenbach, Genl. Elec. Co. Election of officers: Hans Passburg, chmn.; L. C. Packer, vice-chmn.; J. J. Finn, secy.-treas. April 11. Att. 54.

### Toronto

New Utility Given Mercury Arc Rectifiers by Sectionalizing, by A. L. Atherton, Westinghouse Elec. & Mfg. Co. Joint meeting with Engineering Inst. of Canada. April 22. Att. 300.

A Trip Through the Canadian Arctic, by Lawren Harris. Illustrated. Election of officers: I. M. Maclean, chmn.; J. M. Thomson, secy.-treas. April 29. Att. 100.

### Urbana

The Institute and the Electrical Industry—What of Their Future? by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. Joint meeting with Purdue Univ. and Rose Poly. Inst. Branches. April 2. Att. 166.

### Utah

The Public Utility, by G. M. Gadsby, Utah Pwr. & Lt. Co. Dinner. March 7. Att. 37.

The Development of Utah, by A. B. Young. March 30. Att. 45.

### Vancouver

Protective Switchgear for A-C. Power Systems, by D. Robertson, Can. Genl. Elec. Co. Illus. April 4. Att. 55.

The Mercury Arc Rectifier, by L. M. Morton, Genl. Elec. Co. April 25. Att. 50.

### Worcester

Electric Heating Industry, by H. M. Chatto, Genl. Elec. Co. Feb. 29. Att. 38.

Tramways, by E. T. Reardon, Am. Steel & Wire Co. March 17. Att. 20.

Recent Development in the Application of Electric Motor Drives in the Paper, Textile, and Machine Tool Industries, by H. F. Banan and F. D. Snyder, Westinghouse Elec. & Mfg. Co. Dinner. April 14. Att. 60.

## Past Branch Meetings

### University of Akron

The Progress of Radio, by John Chenot, student; Refrigeration, by R. A. Gerber, student. Dec. 9, 1931. Att. 15.

The Zeppelin Akron, by J. C. Fessler, student; Some Applications of the Photoelectric Cell, by Sol. Leiboritz, student. Demonstrations. March 9. Att. 11.

Prof. J. T. Walther, counselor, outlined the activities of the A.I.E.E. Frank Marcinkoski, chmn., reported on the student convention held at Haverford Col. April 22. Att. 10.

### Alabama Polytechnic Institute

Ornamental Forestry, by Mr. Evans, Alabama Pwr. Co. April 14. Att. 19.

The Value of Belonging to the A.I.E.E., by Prof. W. W. Hill, counselor. April 21. Att. 10.

Muscle Shoals, by R. Roberts. April 28. Att. 7.

Entertainment. May 5. Att. 42.

### University of Alabama

Business meeting. April 11. Att. 24.

Principle of Uncertainty, by Dr. B. A. Wooten. Election of officers: W. R. Purcell, chmn.; John Marshall, vice-pres.; E. L. Appoloni, secy.; J. Del Coliano, treas. April 25. Att. 45.

### University of Arizona

The Recording of Sound for Sound Pictures, by J. W. Jones, student. April 1. Att. 9.

The Reproduction of Sound in Sound Pictures, by H. E. Stewart, student. April 8. Att. 7.

Speed Control by Electron Tubes of Sound Picture Projectors, by R. H. Carson, student; Some Recent Experiments in Electron Physics, by Dr. E. H. Warner. Dinner. April 15. Att. 7.

### University of Arkansas

Electrical Distribution, by H. H. Lewis, student; Welding Generators, by L. F. Williams, student. Election of officers: L. C. Wasson, chmn.; R. B. Stone, vice-chmn.; C. L. Mowery, secy.; P. H. Johnson, treas. April 11. Att. 24.

### Bucknell University

Discussion. March 21. Att. 10.

All Electric Ship, by John Barton, student. H. Smithgall, Jr., elected secy.-treas., and J. A. Everitt, elected vice-pres. April 18. Att. 18.

Modulation Measurements by Oscillograph on Radio Station WPSC, by D. H. Smith and R. F. Carlson, Penn. State Col.; Graphical Solutions of Alternating Currents, by James Dobbie, Bucknell Univ. Joint meeting with Penn. State Col. April 27. Att. 49.

### California Institute of Technology

Some Recent Developments in Telephone Communication, by C. A. Wells, Southern Calif. Edison Co., Ltd. April 15. Att. 18.

### University of California

Engineering Opportunities in Foreign Countries, by R. W. Shoemaker. C. Van Camp, student, described the work being done in the physics dept. with high velocity protons. April 12. Att. 30.

### Carnegie Institute of Technology

Smoker. April 22. Att. 59.

The Work of a Control Engineer, by A. C. Dyer, Elec. Controller & Mfg. Co. Election of officers: W. Uffelman, chmn.; R. S. Fish, vice-chmn.; Wm. H. Nichols, secy.; S. J. Hyle, treas. May 4. Att. 20.

### Case School of Applied Science

Election of officers: N. T. Dennis, vice-pres.; W. C. Jenner, secy.; C. L. Fantur, treas. May 4. Att. 40.

### Catholic University of America

Problems Confronting the Engineers of Modern Telephone Companies, by Francis Wheeler, Chesapeake & Potomac Tel. Co. April 13. Att. 40.

### Clarkson College of Technology

Demonstrations and luncheon. Guests of the Science Club of St. Lawrence Univ. April 5. Att. 25.

Motion pictures. April 18. Att. 47.

Election of officers: B. Zimbee, chmn.; J. Sullivan, secy.; W. Harper, treas. April 28. Att. 27.

### Clemson Agricultural College

Engineering Features of Three Power Locomotives, by J. L. O. Foster, student; Steam vs. Electricity for Driving Power Station Auxiliaries, by H. A. Clayton, student; The Future Engineer, by S. E. Lowry, student. Feb. 18. Att. 28.

Stability Experiences With Conowingo Hydro Plant, by A. E. McCall, student; Tape Armored Telephone Toll Cable, by T. M. Watson, student; A Corona Tube Voltage Regulator, by H. M. Rogers, student. March 17. Att. 17.

Interconnections of Electric Power Systems, by W. W. Dickson, student; A Quiet Power House, by F. H. Williams, student; A Portable Radio Beacon, by W. H. Gist, student. April 7. Att. 30.

### University of Colorado

Election of officers: S. W. Hannah, pres.; A. E. Logan, vice-pres.; J. S. Kenyon, secy.; E. C. Sparrow, treas. April 6. Att. 20.

Prof. M. S. Coover outlined the activities at the summer convention held last June. April 20. Att. 25.

The Application of Electricity to Mining on the Witwatersrand, by E. A. Faber; A Study of Rectifier Filter Systems Used in Communication Systems, by F. Wickenkamp, Univ. of Wyoming; Applications of Non-Linear Circuits to Electrical Engineering Problems, by F. W. Cooper and T. M. Austin, Univ. of Colo.; Magnetism and Diamagnetism, by E. R. Gertner and E. Olcott, Univ. of Denver. Joint meeting with the Denver Sec., and students of Univ. of Denver, Colo. School of Mines, Colo. Agri. Col., and Univ. of Wyoming. April 29. Att. 65.

**University of Denver**

Experiences as a Copper Metallurgist in Chile, by Carol Craven. Illus. April 8. Att. 28.

Annual conference on student activities of District No. 6. April 15–16.

**Drexel Institute**

Students attended the student Branch convention held at Haverford Col. March 14.

Insulator String Potentiometers, by A. F. Werner, student. March 16. Att. 17.

**Duke University**

History of Electricity, by T. Finger, student. April 28. Att. 13.

**University of Florida**

Problems Facing a Young Engineer and the Qualifications He Can Offer, by Mr. Garlington, Florida Pwr. Corp. April 20. Att. 55.

Election of officers: G. W. Hostettler, chmn.; J. E. Caraballo, vice-chmn.; E. A. Barnes, secy.-treas. May 2. Att. 15.

**Georgia School of Technology**

Inspection trip through the Southern Bell Tel. & Tel. Co. April 19. Att. 52.

**Harvard University**

Audible Light, by J. B. Taylor, Genl. Elec. Co. April 18. Att. 350.

**University of Idaho**

Banquet at which Prof. R. H. Hull gave a talk on electric railways. Nov. 24, 1931. Att. 21.

Banquet and talk on electric refrigeration. Dec. 16. Att. 26.

Some Developments in Talking Pictures, by K. P. Kenworthy, Univ. of Idaho; The Calibration of a Dynatron Oscillator From Broadcast Harmonics, by Melvin Herr, Wash. State Col.; Power System Frequency Control, by Clarence Cannon, Wash. Water Pwr. Co. Joint meeting with Spokane Sec. and Wash. State Col. Branch. March 25. Att. 65.

Stocks and Bonds, by Dean Farmer. April 19. Att. 18.

**University of Illinois**

Electrical engineering show. March 31–April 1–2.

Business meeting. April 13. Att. 20.

The Manufacture of Impregnated Paper Cables, by R. J. Wiseman, Okonite Callender Cable Co. April 27. Att. 175.

Muscle Shoals, by D. B. Allabough, student. May 3. Att. 25.

**Iowa State College**

The Electrical Industry of Today, by Dr. C. E. Skinner, pres. A.I.E.E., asst. director of engg., Westinghouse Elec. & Mfg. Co. March 24. Att. 160.

Banquet. April 15. Att. 170.

**University of Iowa**

Improvement of the Upper Mississippi River and Its Relation to Transportation, by Col. G. E. Edgerton. April 13. Att. 124.

Thyratron Tubes and Their Uses, by L. F. Balluff, student; Electrostatic and Magnetic Systems of Units, by J. E. Weyland, student. April 20. Att. 35.

Mr. Fortier, Northwestern Bell Tel. Co., gave a demonstration of the dial telephone system. April 27. Att. 44.

Synchronous Motors and Their Adaptability, by C. A. Bartholow, student; New Type of Hoist and Crane, by L. E. Travis, student. May 4. Att. 31.

**Kansas State College**

The Telephone as a Business, by Bob Gray, United Tel. Co. April 7. Att. 60.

**University of Kansas**

Banquet. April 8. Att. 140.

Television, by C. B. Brown, First Natl. Television, Inc. April 14. Att. 46.

Characteristics of Transformer Oil, by L. Sharp and J. D. Swafford, Univ. of Kansas; Russia, by J. C. Bradley, Kansas State Col.; Quality Comparison Between Problems in Engineering and Problems in Psychology, by Prof. R. H. Wheeler, Univ. of Kansas; Application of Weston Photronic Cell to Sound on Film Reproduction, by L. Farber and H. Lanning, Univ. of Kansas. Joint meeting with Kansas St. Col. Branch. May 5. Att. 100.

**University of Kentucky**

A Brief Study of the Vacuum Tube, by W. A. Hunter, student. Feb. 10. Att. 40.

The Mercury Arc Rectifier, by Prof. E. A. Bureau. March 23. Att. 36.

**Lafayette College**

Prof. L. J. Conover nominated for counselor. April 29. Att. 20.

Armature Windings, by K. T. Sutton, student; The History, Types, and Applications of the Photoelectric Cell, by M. Ziev, student. May 5. Att. 20.

**Lehigh University**

Mercury Vapor Rectifiers, by G. M. Kaleda, student; Direct Current Transmission, by Prof. S. S. Seyfert. Election of officers: B. D. Beach, pres.; C. W. Cooper, vice-pres.; Wm. D. Hickman, secy.; J. R. Fritz, treas. May 5. Att. 30.

**Lewis Institute**

Romance of Metals and Metal Separation, by Dr. P. B. Woodworth. May 5. Att. 185.

**University of Louisville**

Phase Advancers, by E. B. Wagner, student; Advances in Railroad Electrification—Especially European, by Mr. Kimball, student. April 22. Att. 14.

**University of Maine**

Electric Transportation, by L. Randall; Control Devices, by R. C. Brooks; Research and X-Ray Apparatus, by H. Poland; Radio, by B. Wood; Lighting, by E. Adams; Switchgear, by W. S. Davis; Marine Equipment, by L. Barrett; all students. April 14. Att. 15.

Election of officers: J. P. Gonzals, chmn.; Gerald Frost, vice-chmn.; John P. Scott, secy.; F. E. Neal, treas. April 26. Att. 9.

**Marquette University**

Election of officers: H. A. Koepp, chmn.; C. M. Warver, secy. April 7. Att. 36.

Business meeting. April 26.

**Michigan College of Mining and Technology**

Electro-Metallurgy, by F. Tolonen. Film—"Construction of Welded Pipe." April 8. Att. 15.

**Michigan State College**

Election of officers: W. C. Wright, chmn.; G. H. Kempfer, vice-chmn.; M. L. Johnson, secy. April 26. Att. 26.

**University of Michigan**

The Job Ahead, by T. N. Lacy, Mich. Bell Tel. Co., vice-pres. A.I.E.E.; Benjamin Franklin, by Prof. B. F. Bailey; The Wind Line Investigation, by Prof. W. G. Dow. Dinner. Inspection trips. Joint meeting with students of Detroit Inst. of Tech., Michigan St. Col., and Univ. of Detroit. April 28. Att. 170.

**School of Engineering of Milwaukee**

The Value of Research in Engineering, by H. L. Greusel, student; Cathode Ray Oscillograph, by L. J. Killian and E. S. Priem, students. Demonstration. April 13. Att. 84.

**University of Minnesota**

Discussion and motion pictures. April 5. Att. 18.

Inspection trip. April 21. Att. 95.

**Missouri School of Mines and Metallurgy**

Motion pictures. April 15. Att. 145.

**Montana State College**

Organization and Duties of the A.I.E.E., by Dean H. V. Carpenter, State Col. of Wash., vice-pres. A.I.E.E. Luncheon. Feb. 25. Att. 105.

New Types of Photoelectric Cells, by M. T. Severud, student; Communication With Light, by J. O. Laird, Student; Flathead Power Development at Polson, by E. Rothfus, student. Rudolph Stoken elected chmn. March 3. Att. 93.

From Apprentice Boy to Immortal, by J. Norlin; Effects of Ultra-Violet Radiation Upon the Eye, by R. Wyman; The Telephone Spans the Pacific, by C. Anderson; Insulation Materials, by H. A. Beck; 1931 Accomplishments in Telephone Field, by E. Blanchard; Electrical Apparatus for Trolley Buses, by D. A. Nauck; all students. April 14. Att. 82.

Guiding Planes by Radio, by V. Bauer; Distributing Programs in the Waldorf-Astoria, by J. W. Cromer; Automatic Voltage Regulation for Master Oscillator, by R. V. Dean; Cable Service Uninterrupted Though Channel Is Dredged, by L. Eisele; Street Lighting at Intersections, by M. Hilden; Electric Drive for Plant Auxiliaries, by J. G. Lightfoot; all students. March 31. Att. 86.

Operating Economies of Diesel Electric Locomotives, by C. L. Grebe; "Dead Spots" and How to Cure Them in Receivers, by J. D. Mathews; Interconnection of Electric Power Systems, by E. Rothfus; New Parking Device, by C. Schmitz; Some History of the Modern Telephone, by R. Stokan; all students. Victor Bauer elected secy.-treas. and J. Lightfoot elected vice-chmn. April 18. Att. 87.

The Boulder Dam Project, by L. Estey; D-C. Electric Coil Turn Counter, by E. Fisher; Electric Hotbeds, by V. Hankins; The Reliability of the Electron Tubes in Electric Service, by C. Hanson; all students. April 21. Att. 80.

Synchronous Electric Time Service, by R. Macdonald; Why Do Power Companies Plant Trees? by E. Dolum; Electrical Cooking Demonstrations, by P. B. McAdam; The Photomic Cell, by J. Joyce; Easy to Test Ground Circuit, by G. Misevic; Storage Battery Trucks for Short Haul Transportation, by E. Hughes; all students. May 5. Att. 83.

**University of Nebraska**

Discussion and demonstrations on transients, by Prof. L. A. Bingham and Mr. Bollman. April 27. Att. 43.

**Newark College of Engineering**

Welding, by S. Fishman. Election of officers: J. G. Woehling, pres.; A. E. Day, vice-pres.; L. Kufyniak, treas. April 18. Att. 25.

**University of New Mexico**

The X-Ray and Its Development, by Harold Deck, Genl. Elec. Co. May 5. Att. 25.

**New York University**

Election of officers: Wm. J. Sutton, chmn.; C. E. Hutchinson, secy. April 19. Att. 16.

**North Carolina State College**

Election of officers: L. G. Atkinson, chmn.; W. C. Cheatham, vice-chmn.; Joseph Salem, secy.-treas. April 19. Att. 31.

Diesel Engine Features, by Prof. W. J. Dana; Recent Electrical Inventions, by C. M. Smith, student. May 3. Att. 16.

**University of North Carolina**

Election of officers: F. S. Black, chmn.; G. R. Mamin, vice-chmn.; G. E. Hunter, secy.; T. C. Evans, Jr., treas. New Corpuscular Theory of Radiant Energy (or Light), by Dr. E. K. Plyler. May 3. Att. 60.

**North Dakota State College**

Election of officers: L. Schweha, chmn.; R. Netherland, vice-chmn.; Vance Schneider, secy.-treas. April 9. Att. 23.

**University of North Dakota**

Radio Receivers, Advantages of the Superheterodyne, by A. Stratmoen, student; Ultra High Frequency Radio, by R. C. Moore, student. April 13. Att. 15.

**University of Notre Dame**

New Developments in Telephony, by J. A. Barkson, Amer. Tel. & Tel. Co. Joint meeting with Engrs.' Club. April 4. Att. 129.

Electrons at Work and at Play, by Dr. Phillip Thomas, Westinghouse Elec. & Mfg. Co. April 12. Att. 550.

Radio in General, by P. A. Darmody, student; Standard Dielectric Test for Sheet Insulating Materials, by R. V. Bugni, student; V. E. Plante, Allis-Chalmers Mfg. Co., gave a talk on synchronous condensers and synchronous machines in general. Mr. Scanlon, student, presented the usual engineering digest. April 18. Att. 56.

**Ohio Northern University**

Election of officers: Donald Pees, pres.; Bernard Hauber, vice-pres.; Edgar Wagner, secy.; C. Williams, treas. April 7. Att. 26.

**Ohio State University**

Discussion. April 6. Att. 16.

The Electric Shock, by Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres. A.I.E.E. Joint meeting with Columbus Sec. April 22. Att. 36.

**Ohio University**

The Use of the F-P54 Pliotron in the Measurement of X-Ray Absorption Coefficients, by J. E. Edwards, student. April 20. Att. 12.

**Oklahoma A. & M. College**

Manufacture and Use of Metallic Diamonds, by Guy Keiser, student; Gyroscopic Balance for Large Ships, by P. Bobo, student. April 11. Att. 15.

Some Aspects of Lighting, by T. Hutchinson, student; Mercury Arc Jet Rectifiers, by Lynn Cox, student. Election of officers: William Trimble, chmn.; J. R. Hollis, vice-chmn.; F. Zook, secy. April 26. Att. 20.

**University of Oklahoma**

Discussion. Feb. 18. Att. 20.

Major Developments of Radio, Particularly Its Application to Aviation, by Prof. Farrar. March 17. Att. 17.

Short Cut Calculation on the Parallel Surface, by H. Moody, student. April 14. Att. 17.

**Oregon State College**

Recent Trends in Electric Apparatus Developments, by A. W. Copley, Westinghouse Elec. & Mfg. Co., vice-pres. A.I.E.E. Hoover Dam, by C. F. Swigert, Pacific Bridge Co. April 11. Att. 70.

**Pennsylvania State College**

Fundamentals of Television, by Prof. E. B. Stabely. Demonstrations. April 15. Att. 106.

**Pratt Institute**

Step by Step Machine Switching Dial Telephone Equipment, by F. J. Skerritt, student; Panel Switching for Automatic Telephone Systems, by E. F. Zawachi, student; Operation of Selector Switch as Used in Step by Step Machine Switching Dial Telephone Equipment, by K. D. Porter, student; Electrical Equipment in an Industrial Plant, by A. Tiffany, student. April 14. Att. 25.

**Purdue University**

Effects of Frequency in Communication, by J. L. Wayne, Indiana Bell Tel. Co. April 12. Att. 45.

Iron—Nickel Alloys, by Dr. M. A. Hunter. March 15. Att. 50.

**Rhode Island State College**

After Graduation, What? by G. B. Nichols. April 14. Att. 52.

B. G. Lamme, by J. Costanza, student; C. P. Steinmetz, by Wm. Daly, student. April 21. Att. 10.

**Rice Institute**

Discussion of plans for engineers' show. March 23. Att. 27.

Discussion. April 20. Att. 21.

**Rutgers University**

An Investigation of Leakage Flux of Transformers, by F. P. Fisher, student. April 12. Att. 14.

**University of Santa Clara**

Business meeting. March 18. Att. 39.

Inspection trip. April 7. Att. 49.

Joint meeting with San Francisco Sec., and Univ. of Calif. and Stanford Univ. Branches. (See report under "Past Section Meetings.")

Election of officers: J. Russell, chmn.; J. A. O'Neil, vice-chmn.; M. Hermes, secy.-treas. May 2. Att. 9.

**University of South Carolina**

Election of officers: A. R. Urquhart, chmn.; H. G. Smith, Jr., vice-chmn.; E. C. Salley, secy.-treas. March 3. Att. 34.

Oil Electric Car in Mixed Train Service, by D. J. Delk, student; Latest Miracles of the X-Ray, by H. Howard, student; Water for Chicago's Growing Populace, by J. J. Duffie, student. April 14. Att. 33.

Relay Control Equipment at Saluda Dam, by E. P. Miller, Associated Gas & Elec. Co. April 21. Att. 101.

Inspection trip to the Saluda Dam. April 28. Att. 40.

**South Dakota State School of Mines**

Harold Hayes, student, outlined his experiences while employed by the Northwestern Bell Tel. Co. Rex Tario, student, described the inspection trip through the Homestake Mine. April 12. Att. 22.

Harold Fry, chmn., gave a résumé of the conference on student activities of District No. 6, held in Denver. April 19. Att. 40.

**University of South Dakota**

Election of officers: L. Johnson, chmn.; W. Houck, vice-chmn.; N. Larson, secy.-treas. April 11. Att. 10.

**University of Southern California**

Discussion. April 6. Att. 18.

Beach party. April 20. Att. 84.

Sound Recording Process, by Mr. Cummings, United Artists Film Corp. April 27. Att. 22.

**Southern Methodist University**

Thyratron Tubes, by J. V. Melton, student; Deion Circuit Breakers, by J. W. Emery, student; Recent Developments in Radio Tubes, by D. Ramsey and J. N. Walker, students. Jan. 8. Att. 80.

Engineers Day. Over 2,000 visitors. March 18.

Prequalification and the Lowest Responsible Bidder, by J. Wallace Emery, student; Procedure and Details of Turbine Overhaul, by E. W. Garrett, student. April 5. Att. 18.

**Stevens Institute of Technology**

Yacht Design, by Warren Riker, student. April 1. Att. 30.

The Importance of Mathematics, by Prof. R. F. Deimel. Luncheon. April 12. Att. 35.

Smoker. What an Engineer Should Know About Patents and the U. S. Patent System, by W. H. Taylor, Jr., Pennis, Davis, Marvin & Edwards. Films—"Conquest of the Cascades" and "The Construction of Small D-C. Motors." Photoelectric Cells, by Dr. Harvey C. Rentschler, Westinghouse Lamp Works. April 15. Att. 100.

**Syracuse University**

Electrical Discoveries and Experiments Leading to the Discovery of Radium, by H. E. Coswell, student; Theory of the Mercury Arc Rectifier, by E. Murphy, student. April 15. Att. 21.

History and Development of Electric Refrigeration, by J. W. Truran, student. April 22. Att. 21.

Inspection trip to the Solvay substation. April 25. Att. 21.

Theater Lighting, Pre-Set Boards, by T. J. Kelly, student. April 29. Att. 20.

**University of Tennessee**

Discussion. Jan. 14. Att. 34.

Election of officers: M. G. Toole, chmn.; L. G. Cockrill, vice-chmn.; H. H. Gnuse, Jr., secy.-treas. March 31. Att. 31.

Advantages of the A.I.E.E., by Prof. J. G. Tarboux, counselor. April 13. Att. 62.

**Texas A. & M. College**

The Design of High Voltage Lines Against Lighting Surges, by A. O. Austin, Ohio Brass Co. Talk by Col. H. S. Crocker, pres. A.S.C.E. April 14. Att. 36.

**University of Texas**

Development in the Electrical Industry in 1931, by W. D. Clayton and H. F. Allen, both of the Genl. Elec. Co. March 23. Att. 63.

Insulators, by A. O. Austin, Ohio Brass Co. April 19. Att. 62.

The Development of Public Utilities, by David Laves. April 28. Att. 10.

**University of Utah**

Cutler Dam Power Plant, by S. Kettleman, Utah Pwr. & Lt. Co. Election of officers: Frank Carman, chmn.; G. E. Bossard, vice-chmn.; Simon Ramo, secy.-treas. April 27. Att. 30.

**University of Vermont**

The Magnetic Properties of Compressed Powdered Iron, by F. P. Kenyon, student. Hydrogenized Iron, by Prof. Buchanan. April 11. Att. 18.

**Virginia Military Institute**

The Development of Gaseous Tube Lighting, by H. J. Geiger; The Magnetic Compass, by J. H. Carrico; The Motive Power for Suburban Electric Lines, by W. C. Landis; Vacuum Tubes in Industry, by J. T. Meek; The Improvements Around Niagara Falls, by S. J. Mergenhagen; all students. April 9. Att. 51.

What Big Business Expects of the College Man, by R. C. Saunders; Teletype Communication, by P. C. Wooters; Plane Dispatching on the Big Airlines, by W. W. Holt; Electricity in Advertising, by T. L. Moore; Visit Conowingo, by E. R. Trapnell; all students. March 19. Att. 74.

The Engineer and His Responsibility as a Citizen, by L. Hilliard; Torque-Angle Characteristics of Synchronous Machines Following System Disturbance, by S. A. Singleton; Trouble Shooting on a Highline, by H. A. Longino; U. S. Navy Requirements for Diesel Engines, by W. M. Cummings; Underworld Broadcasting Stations, by L. DeCamps; all students. May 2. Att. 43.

**Virginia Polytechnic Institute**

Increasing Brush Capacity, by G. R. Elder; A Study of Lighting on Transmission Lines, by E. W. Whitmer; The Operation of Mercury Vapor Turbines, by N. L. Gregg; The Point-O-Lite, by A. R. Neal; Hydroelectric Plant at Lynchburg, Va., by M. L. Simpson; all students. April 21. Att. 27.

Election of officers: P. H. Cross, chmn.; N. L. Gregg, vice-chmn.; W. L. Young, secy. May 5. Att. 43.

**State College of Washington**

The Electrification of the Great Northern Railway Through the Cascade Tunnel, by G. H. Walker, Great Northern Railway. Film—"The Conquest of the Cascades." April 15. Att. 130.

Problems Arising With the Commercial Engineer, by B. H. Collison, Pacific Tel. & Tel. Co. April 19. Att. 52.

**University of Washington**

The Power Possibilities of the Columbia River, by Eugene I. Pease. April 18. Att. 22.

Commercial Uses of the Vacuum Tube, by J. T. Copley, Genl. Elec. Co. April 20. Att. 79.

Glenn Parker, U. S. Geological Survey, spoke on water power sites and stream gaging. May 3. Att. 128.

**Washington University**

Electrons at Work and at Play, by Dr. Phillips Thomas, Westinghouse Elec. & Mfg. Co. Demonstrations. May 1. Att. 250.

**West Virginia University**

Telephone, by R. W. Blair; Powdered Fuel and Ash Precipitation, by P. Skaff; Springdale Power Plant, by J. L. Simpson; Westinghouse High Tension Laboratory, by M. L. Sprigg; Pittsburgh Equitable Meter Co., by J. Kayuha; Colfax Power Plant, by C. J. DeLancy; Pittsburgh Telephone Exchange, by E. L. Engle; Electrical Equipment of the Carnegie Steel Co., by A. W. Friend; Pittsburgh Equitable Meter Co., by W. C. McMillion; all students. April 12. Att. 29.

Westinghouse Radio Station KDKA, by D. C. Kennedy; Electrical Equipment of the Carnegie Steel Co., by H. V. Locker; Elevator Hoisting Equipment and Control, by E. J. Williams; Direct Strokes in Transmission Lines, by J. E. Wallace; Mesta Machine Co., by V. S. Monteith; Westinghouse Elec. & Mfg. Co., by P. Vannoy; High Tension Testing Laboratory, by L. Kirwin; Springdale Power Plant, by C. J. McCormick; all students. April 19. Att. 29.

**University of Wyoming**

Labor, by E. K. Nelson, city engr. Joint meeting with A.S.M.E. Branch. April 12. Att. 11.

## Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Andreae, S. C., 2224 Charnwood Ave., Los Angeles, Calif.
Archbold, Earl J., Box 2641, Birmingham, Ala.
Brentnall, E. L., W. R. Hendrey Co., Hoge Bldg., Seattle, Wash.
Bugg, Vernon, 736 Transportation Bldg., Washington, D. C.
Grable, Joseph P., Genl. Cable Corp., Ft. Wayne, Ind.
Iwe, Halfdan G., 229 Ovington Ave., Bklyn., N. Y.

Miyamoto, Tatsuo C., 1330-4th St., Sacramento, Calif.
Palit, Hari-Charan, 151 Ganesh Mohal, Benares City, India.
Rogge, C. A., Consumers Pwr. Bldg., Jackson, Mich.
Scanlon, D. L., KFPW, Ft. Smith, Ark.
Schwartz, Carl, 410 Cathedral Pkwy., N. Y. City.
Thomas, Earl Mead, Intl. Genl. Elec. Co., Schenectady, N. Y.
Titland, Trygve T., 1019 Stanton Ave., Elizabeth, N. J.
Van Ness, L. G., 2105–6 Sterick Bldg., Memphis, Tenn.
Vetri, L., Western Elec. Co., Inc., 100 Central Ave., Kearny, N. J.

# Employment Notes

## Of the Engineering Societies Employment Service

## Positions Available

LARGE ELEC. AND MECH. MFG. CONCERN in Europe requires an executive designing engr. for their oil switch division. Fully trained E.E. of Swiss origin, thoroughly experienced in the modern design and construction of high tension overhead equipment, especially oil switches. Must have executive ability and speak German fluently. Apply by letter stating complete information as to age, education, experience, references, salary, etc. W-3754-CS.

A COMPANY MFG. a diversified line of elec. apparatus wishes to fill the position of supt. in a medium size plant in the Middle West. Applicant must be a graduate of a tech. univ., have a good personality, executive ability, and a knowledge of modern mfg. methods and equipment, supported by 10 to 20 yr. actual experience. Apply only by letter. W-3780-R-501-C.

## Men Available

### Agents' Representatives

MFRS'. AGT. OR SALES ENGR., sales connection desired, 42. Twelve yr. engg., 8 yr. sales experience. Tech. col. education and also war training at naval academy. Willing to go anywhere—New England States preferred. D-783.

### Construction

ELEC. CONSTRUCTION ENGR., 33; 10 yr. practical experience in elec. construction work on new buildings. Familiar with all branches of electrical contracting, including estimating, field engg., and purchasing. Has been in complete charge of elec. work in various large building projects in New York City. A-850.

### Design and Development

E.E. GRAD., 31, single, 8 yr. experience in design of regulators and transformers. Desires position with utility or mfg. concern. Location, immaterial. Available on short notice. Excellent references. D-774.

ELEC. DESIGN ENGR., A.B., E.E., 33, married, Westinghouse elec. design school. Nine yr. responsible experience in design of d-c. motors and generators; also successful development work. Expert on commutation. Desires design work or teaching. Available on short notice. Location, immaterial. C-201.

E.E. GRAD., 28, married, 6 yr. experience in ry. signal engg. steam and elec. rys. Familiar with circuit design, estimating, installation, and maintenance of a-c. and d-c. signaling equipment. Also 1 yr. experience on steam r.r. electrification. Willing to go anywhere. C-6914.

ELEC. AND MECH. DESIGN ENGR., 41, 16 yr. experience in design and development of elec. apparatus for large quantity production; 5 yr. specializing in cost reduction design on apparatus in highly competitive field. Experience covers control apparatus, radio, refrigeration, and talking pictures. Best of references. East preferred. Available immediately. C-4977.

ELEC. DESIGNER, col. grad., 15 yr. engg. experience, comprehensive knowledge design of generating plant and substation. Expert switchboard engr., including diagrams, control, relays, etc. Desires position with utility. Available immediately. Location, immaterial. D-482.

ELEC. DESIGNER ENGR., 30, single, 10 yr. experience in design of complete elec. systems, substations, hydro-stations, industrial maintenance. Responsible, capable asst. to engr. Educated in Sweden, B.S. in E.E., American citizen, linguist. Location, immaterial. D-914.

### Executives

MEMBER, 42. Extensive and diversified executive experience here and abroad. Communications engg.; utilities; corporate organization and mgmt.; personnel; sales. Contacts everywhere. Unusual and easily verified record of achievement. Qualified as a corporate secy., treas., sales engr., or as asst. to busy executive. D-730.

ELEC.-MECH. ENGR., 36, 6 years' consulting experience with large western firm, architects and engrs. Contact man. Entire charge large projects in central station and industrial field. Seven yr. design and construction large eastern utility. Registered New York. Speaks French. Will consider anything anywhere. Available May 15. D-52.

E.E., 37, married, 12 yr. experience in design of substations, elec. installation of ships, statistics, valuation, estimates. Best references from large firms in Germany and U.S. Prefer to represent American firm in Germany, Austria, or Switzerland. D-812.

E.E., grad., 42, 5 yr. supervision elec. maintenance r.r. Six yr. head elec. and mech. maintenance group of coal mines. Eight yr. assoc. editor coal mining magazine, experienced equipment photography, wide acquaintance, numerous excellent references. B-7563.

SUPT. of distribution, grad. Lowell Inst. Sch., auspices Mass. Inst. of Tech., elec., industrial mgmt. courses, 44, married. Twenty yr. elec. utility operating experience, engg., instruction, operation, maintenance of distribution, transmission lines, substations, transportation, first aid, and educational work. Has sufficient utility operating experience to qualify for position of supt. C-8411.

E.E., married, E.E., M.E. Twenty-two yr. experience, designing, construction pwr. plants, substations, transmission, distribution systems, industrial plants. Three yr. charge purchasing engineering equipment, foreign interests. Three yr. executive experience charge engg. dept. large utility syndicate. English, German, Russian, Armenian languages. Available immediately. D-84.

E.E. GRAD., Univ. of Wis., 33, single, 3 yr. Westinghouse Test, 7 yr. supervising pwr. plants, substations, transmission line construction. Four yr. engg. inspection, purchasing, expediting, tracing, res. engr., and writing specifications. Excellent reference. Can handle responsibility. Wants connection, utility, holding company, contractor, or mfr. Available immediately. Location, immaterial. B-9661.

E.E., 40. Eighteen yr. operating and engg. experience with large pwr. companies and in central holding company's engg. dept. Desires position as chief engr. small or moderate sized company or as asst. for large company. C-9291.

E.E. GRAD., 32, single, valuable experience in construction and E.E. dept. of large utility and as asst. genl. mgr. with mfr.; also selling experience. Glad to furnish references. Very willing to travel over large territory. Location, immaterial. D-745.

GRAD. ENGR., American, 27 yr. experience in design, erection, operation, and maintenance of all kinds of machy. Recently in charge of 35,000-hp. elec. installation. Expert on central station rates and contracts. Small salary acceptable in order to secure employment. C-6200.

E.E., E.E. degree. Fourteen yr. experience utilities covering valuation work, rate investigations, engg. pwr. plants, substations, transmission lines, including estimates, specifications, design. Experience covers short circuit studies, stability analysis, investigations of systems for load conditions. Desires position, holding company, operating company, or engg. firm. Available immediately. C-9570.

E.E., 40, married, 18 yr. experience utilities and industrial plants as mgr., supt., chief engr., wide experience steam, Diesel, hydro plants, manufactured gas, telephone, utility accounting. Good record, excellent references. Accept anything. Available immediately. Location, no preference. D-909–325-C-1-San Francisco.

E.E. GRAD., married, 20 yr. experience abroad and in U.S.A. estimating, designing, and inspection of elec. pwr. and light layouts, including 2 yr. charge of elec. and steam plant in iron mine, 6 yr. research and 2 yr. sales experience in lamp and metal industries. Available at once. B-9034.

EXECUTIVE. E.E., grad., married, 30 yr. experience mgr., supt., elec. engr., construction, operation, utilities. Installed steam-Diesel-hydroelectric plants. Building substations, transmission lines, distributing systems, street car network, laying underground and undersea cables. District mgr., sales representative for mfrs. of H.T. oil circuit breakers, switches, transformers. Available now. B-2388.

E.E., 30, married, 5 yr. transmission, distribution dept., utility, 2 yr. chief engr. talking moving picture company, $1\frac{1}{2}$ yr. engr., wiring specifications for architects of tel. & tel. buildings. One yr. experience making Neon tubes. Designed, made apparatus for making "structural stress" and "wind pressure" test in Empire State Bldg. C-6577.

E.E., univ. grad., pwr. experience, desires position with pwr. or mfg. company. Development work preferred but not essential. B-1923.

E.E., Univ. of Ill., 12 yr. experience in design, manufacture, and sales of elec. machinery. At present chief engr. and sales mgr. Middle West

## ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
San Francisco

205 West Wacker Drive
Chicago

31 West 39th St.
New York

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

**Men Available.**—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

**Opportunities.**—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

**Voluntary Contributions.**—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

**Answers to Announcements.**—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

plant mfg. elec. motors. Can handle designing, sales, or plant operation. Available soon. Location, immaterial. C-7029.

### Inspection

ENGR.-INSPECTOR. Past 8 yr. in charge of inspection dept. of large transformer mfr. Ten yr. design experience. E.E. deg. Desires position, preferably as head of inspection dept., but will consider other lines in which transformer experience from drafting board to operation would be of value. B-2409.

### Instruction

FORMER CORNELL INSTRUCTOR IN MACHINE DESIGN for 4 yr., Allis-Chalmers designer and checker 5 yr., M.E. and E.E. deg., shop apprenticeship and miscellaneous experience. 32, single. Desires teaching or engg. opportunity. Salary open. D-122.

UNIV. GRAD., B.S. and E.E. degrees, 41. Experience Westinghouse, utilities, U. S. Government and mining companies. Six yr. asst. prof. of elec. engg. and 1 yr. acting head of elec. engg. dept., state institution. Desires position teaching elec. engg. C-5021.

E.E. GRAD., M.S. deg., 28, married. Two yr. G.E. Test and radio development lab. Three yr. as radio engr. and district service mgr. in charge of service activities in 8 states with large radio mfg. concern. One yr. teaching elec. engg. Location, U.S. Available in June. D-871.

GRAD. E.E., 27, desires position teaching mathematics, E.E. subjects, or lab. work. One yr. G.E. Test, 1 yr. design engr., 3 yr. industrial mgmt. Experienced evening school teacher. Good ability, highest references. Available June. Location, immaterial. D-920.

INSTRUCTOR, grad. E.E. with practical experience in maintenance and as sound engr. D-615.

### Junior Engineers

E.E., 25, B.S. in E.E. in 1930 from mid-western school, location does not make any difference. G. E. Test experience, and about 2 yr. of wiring and repair work. Salary second to a position. D-433.

M.E.E. deg. 1930, Rensselaer Poly. Inst., single, 24, candidate for the deg. of Doctor of E.E. this June, good scholastic record. Desires experience with any utility or mfg. concern or teaching. Salary not of primary importance, available this June. Location, any part of U.S.A. or India. D-469.

GRAD. E.E., 1931, A.B., B.S., 25, single. Substation experience while student. Eight months as draftsman on wire work involving catenary design in connection with r.r. electrification. East preferred. Available immediately. D-795.

E.E., B.S. from Ohio Northern Univ., class of 1932, 23, single and excellent physical condition; willing to work hard. Have had considerable experience as salesman. Interested in any position where an engg. knowledge is required. Excellent references. Correspondence invited. Available in June 1932. Location, immaterial. D-787.

E.E., grad. 1931, Northeastern univ., cooperative plan, 22, single. Three yr. experience test and servicing elec. equipment and motors. Desires connection with construction or utility concern. Location, immaterial. Available at once. D-849.

GRAD. E.E., 27, married. Three yr. with utility on generating and substation design and layout, including switchboard and control. Two yr. industrial pwr. application. Desires position with utility co. or mfg. concern. Location, immaterial. Available one month. D-861.

GRAD. E.E., 22, Rensselaer Poly. Inst. 1930. Member Sigma Xi. Two yr. experience in plant dept. of telegraph company. Desires position with advancement in any engg. field. Salary immaterial at start. Location, North Eastern U.S. Available at once. D-785.

B.S. in E.E. Case Sch. of Applied Science 1929, 27, married; $2\frac{3}{4}$ yr. with ry. signal company in construction, testing, inspection, drafting, circuit design, and creative advertising. Two yr. practical surveying. Thoroughly familiar with the principles of illumination. Available at once. Location, immaterial. D-870.

1931 GRAD. E.E., mid-western college, 24, single. Three yr. experience in genl. maintenance, construction, and motor testing. Location, immaterial. Available at once. D-572.

GRAD. B.A. (Physics), 1932, single, 22. Desires position in elec. industry. Office experience in maintaining charts and statistics. References. Location, South West preferred, but elsewhere considered. Available on short notice. D-822.

E.E. GRAD., 1930, Carnegie Inst. of Tech., 24, single. Laboratory experience while working way through school. Two yr. experience in teletypewriter and telephone communication. Permanent position desired. Available immediately. Location, immaterial. D-881.

B.S. IN E.E. 1932, Brown Univ., editorial and advertising experience. Industrial work preferred. Good mgr., applied psychologist. Thorough understanding of d-c. and a-c. machinery, transmission lines, auxiliary apparatus, testing, and applications. General knowledge includes economics, hydraulics structures, etc. Cultured, industrious, and clever. D-742.

POSITION DESIRED by young engr., 26, col. grad. Has had two yr. G.E. Test and 3 yr. in d-c. dept. of G.E. Company on design and cost estimating of synchronous converters. D-882.

E.E., grad., 1931, 25, single, cooperative college. Twelve months' experience as asst. in production lab. of battery mfg. concern. Six months' experience as a general draftsman. Speaking and reading knowledge of German. Desires position with a future. Location and salary secondary. Available immediately. D-534.

GRAD. E.E., 1931, U. of M., single, 22. Seven months' student sales engr., Wagner E. Test. Nine months' experience elec. maintenance and construction of industrial equipment, Ford Motor Co., six months' salesman. Desires position elec. motor industry or utility with opportunity for advancement. Location, Michigan and adjacent states preferred. Available immediately. D-719.

1931 GRAD., 28, single, 8 yr. machine shop. Wishes any kind of work or study and research to obtain master's degree. Location and salary not material. Available at once. D-916.

E.E., 28, single. Experience in general engg. and research lab. of the G.E. Also 1 yr. of G.E. Test. Desires position with a laboratory, utility, or mfg. concern. Available July 1. Location in the East. D-915.

GRAD. E.E., Columbia Univ. 6 yr. course, 1932; single, 24. Desires work with utility, r.r., mfg. concern, or construction corporation. Would like to teach E.E. subjects. Location and salary immaterial. D-893.

E.E. GRAD., 1932, 24, single. B.S. in E.E. from well-known engg. school. Good scholastic record. Four yr. mfg. experience includes timekeeping, cost work, maintenance, and assembly. Desires position with opportunity for advancement with utility, engg., or mfg. firm. Location preferred, Ohio-Pa. vicinity, but will consider others. D-908.

1931 GRAD., E.E., B.S., leading western univ., 27, single. Telephone work, machine shop apprenticeship, draftsman, and machine designer, familiar with vacuum tubes, good mathematician. Excellent scholastic record. English, German, Swedish, Finnish, and Spanish languages. Desires position with industrial firm. Location, immaterial, U.S. or abroad. Available on short notice. D-923.

1931 GRAD. in E.E., B.S. from Clemson Agri. Col., 25, single. Desires work with utility, mfg. concern, or construction corporation. Available immediately. Location, immaterial. D-400.

STUDENT, 25, single, B.E.E. '32, Univ. of Detroit, 8 yr. radio-telephone experience, $1\frac{1}{2}$ yr. of which with police dept., the rest broadcasting. Would like position with large station or chain, if possible. Location, immaterial. Holds 2nd class commercial operator's license. D-926.

### Maintenance and Operation

E.E. GRAD., 1927, married. Eight yr. steam plant operation and maintenance, and factory maintenance. Now unemployed. Location preferred, Middle West or Western. C-8522.

M.E., E.E., AND C.E., graduated Italy, 30, single. Executive experience. Desires position anywhere with utility or contractor. Three yr. varied civil engg., 2 yr. in pwr. production in steam and hydroelectric plants. Skilled in any layout, topographic, and maintenance work. D-422.

ELEC. RY. ENGR., 36, grad. E.E. Extensive experience in all phases of elec. and street ry. work including plants, substations, transmission, trolley and telephone lines, elec. locos., interurban and city cars, also lighting of steam trains, etc. Record of rapid advancement. Good organizer. Speaks Spanish. C-9557.

### Research

PHYSICIST, 33, married, grad. and post-grad. work at Harvard. Eleven yr. experience in development laboratories, mostly with vacuum tubes and Neon lamps. Good knowledge of high frequency currents and theoretical mechanics. B-8390.

### Sales

SALES MGR.-ENGR., 35, experienced capable sales contact man, desires connection as representative or mfrs. agt. with high grade company mfg. line of high or low voltage equipment for utilities or industrial plants. B-4067.

SALES ENGR., E.E. grad., 30, married, $5\frac{1}{2}$ yr. experience in utility work involving pwr. station operation and maintenance; pwr. station and substation design. Teaching experience. Fourteen months' application sales engg. experience with control mfg. concern. Desires position as salesman or application engineer. Available immediately. D-713.

MFRS. AGT. OR SALES ENGR., British engr. (American papers) mech., elec., 36, single. Thorough knowledge of several British Colonies and Spain. Six years industrial sales engr., specializing industrial heat, large western utility, desires connection American firm contemplating plant or sales office within British Empire, South America. Fluent Spanish, French. Available immediately. D-806.

E.E. GRAD., 30, family, $2\frac{1}{2}$ yr. telephone engr., 2 yr. sales mgr. for automotive jobbing house, 2 yr. field engr. for elec. light company, with a total of $2\frac{1}{2}$ yr. drafting on tool and machine design. Desires work of any kind or type paying living wages. Location, immaterial. C-951.

ELEC.-MECH. ENGR., 39, married. G.E. student course. Eighteen yr. experience sequence motor control systems, industrial engg., sales, patents, investigations and reports, machinery development. Prefers connection as industrial consultant or as sales engr. C-9552.

### Testing

GRAD. E.E., 29, single, B.S., Union College, 1929. One yr. with Underwriters' Lab., 2 yr. Otis Elevator Co., development and test dept. Familiar with all types of elevator and escalator equipment. Desires position designing and testing of industrial control equipment. Available at once. Location immaterial, preferably the South. D-558.

# Membership

## Recommended for Transfer

The board of examiners, at its meetings on the dates given recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the acting national secretary of the Institute.

### To Grade of Fellow (May 18, 1932)

Christie, Clarence V., prof. of elec. engg. and head of dept., McGill Univ., Montreal, Can.
Lovell, Wm. V. (retired), Stanford, Florida
Rees, John B., equip. and bldg. engr., Am. Tel. & Tel. Co., New York

### To Grade of Member (April 13, 1932)

Anderson, Albert S., central station dept., Genl. Elec. Co., Denver, Colo.
Anderson, Henry C., asst. engr., N. Y. & Q. Elec. Lt. & Pwr. Co., Flushing, N. Y.
Blume, Norman H., wire chief, Wisconsin Tel. Co., Madison.
Buchanan, Wm. B., testing engr., Hydroelectric Pwr. Comm. of Ont., Toronto.
Crowdes, George J., asst. elec. engr., Simplex Wire & Cable Co., Cambridge, Mass.
Grauten, S. H., acting development engr., Pub. Serv. Co. of No. Ill., Chicago.
Hayden, C. B., service engr., Pub. Serv. Comm. of Wis., Madison.
Houghton, M. G., supervisor of elec. engg., Detroit Inst. of Tech., Detroit, Mich.
Hull, R. M., division distribution engr., Pa. Pwr. & Lt. Co., Allentown.
Marconi, C. G., elec. engr., Elec. Bond & Share Co., New York.
Perreten, Arnold E., asst. elec. distribution planning engr., Pub. Serv. Co. of Colo., Denver.
Peterson, T. F., consulting cable engr., Am. Steel & Wire Co., Worcester, Mass.

Ready, Lester S., consulting engr., San Francisco, Calif.
Sealey, Wm. C., elec. engr., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Skooglund, Carl M., pwr. station design engr., West Penn Pwr. Co., Pittsburgh, Pa.
Spaulding, G. W., asst. to genl. supt., Pa. Water & Pwr. Co., Baltimore, Md.
Steinberg, Max J., elec. field engr., Brooklyn (N. Y.) Edison Co.
Stevens, Earl E., elec. testing engr., Commonwealth Edison Co., Chicago, Ill.
Weidlein, Wm. D., engr., Black & Veatch, Kansas City, Mo.
Wendell, R. B., design engr., Pub. Serv. Co. of No. Ill., Chicago.

### To Grade of Member (May 18, 1932)

Bostwick, Wm. E., inspector, Pa. R.R. Co., Altoona, Pa.
Burlingham, Kenneth R., chief electrician, Milwaukee County Institutions, Wauwatosa, Wis.
Cockburn, John M., telephone systems engg. dept., Northern Elec. Co., Montreal, Can.
Damania, Sorab B., engr.-in-charge, Ambernath Elec. Supply Serv., Ambernath, G.I.P. Ry., India
Ege, Wm. W., dist. mgr., Copperweld Steel Co., Chicago, Ill.
Ekeroth, Walter M., asst. engr., Brooklyn (N. Y.) Edison Co.
Langwig, Frank I., asst. engr., N. Y. Telephone Co., Albany
Lewis, Ephraim H., genl. mgr., Union Elec. Lt. & Pwr. Co., and St. Louis County Gas Co., Webster Groves, Mo.
Lightband, Denis A., designing elec. engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Tang, Kwan Yau, prof. of elec. engg., Ohio State Univ., Columbus, Ohio
Travers, Fred H., engr., Genl. Elec. Co., Bridgeport, Conn.

## Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the acting national secretary before June 30, 1932.

Brainerd, J. G., Univ. of Pa., Phila.
Briggs, A. S., Jr., Phila. Elec. Co., Phila., Pa.
Campbell, F. W. (Member), Westinghouse Elec. & Mfg. Co., Cleveland, Ohio
Carlson, E. J., Univ. of Calif., Berkeley
Casavant, F. C., Syracuse (N. Y.) Lt. Co., Inc.
Coffinberry, C. M., Elec. Engg. Sales Co., Los Angeles, Calif.
Crump, L. L. (Member), James R. Kearney Corp., St. Louis, Mo.
Davidson, L. A., Okla. Gas & Elec. Co., Oklahoma City
Deming, A. F., Natl. Advisory Committee for Aeronautics, Langley Field, Va.
Harrison, E. T. G., Southwestern Bell Tel. Co., Oklahoma City, Okla.
Held, C. A. (Member), Monks & Johnson, Boston, Mass.
Henshaw, W. J., Vancouver Pwr. Co., Lake Buntzen, B. C.
Hoover, H. C., Wagner Electrical Corp., Washington, D. C.
Johnston, A. B., Southwestern Bell Tel. Co., Oklahoma City, Okla.
La Chapelle, H. C., Am. Tel. & Tel. Co., Denver, Colo.
Luckenback, C. E., York Ice Machinery Corp., York, Pa.
Mahaney, D. J., Southwestern Bell Tel. Co., Oklahoma City, Okla.
McCluskey, F. J., James R. Kearney Corp., St. Louis, Mo.
McLean, C. H., British Columbia Telephone Co., Vancouver, B. C., Can.
Parkhurst, E. T., 79 Walnut St., Somerville, Mass.
Pedersen, A. H., Automatic Temperature Control Co., Germantown, Phila., Pa.
Pendleton, V. A., Oklahoma Gas & Elec. Co., Oklahoma City
Powers, C. F., New England Pwr. Engg. & Serv. Corp., Boston, Mass.
Reese, L., Pacific Gas & Elec. Co., San Francisco, Calif.
Risen, H. J., Okla. Gas & Elec. Co., Oklahoma City
Schroeppel, H. C., Memphis Pwr. & Lt. Co., Tenn.
Todd, J. M. (Fellow), 818 Maritime Bldg., New Orleans, La.
Vance, R. L., Bell Telephone Labs., N. Y. City
Wall, W. W., Natomas Co., Natoma, Calif.
Woll, L. B., 741 Fairmount Place, N. Y. City
30 Domestic

### Foreign

Headland, H., Public Wks. Dept., Waitaki Hydro, South Island, N. Z.
Hickey, M. G., Hackbridge Elec. Construction Co., Hersham, Walton-on-Thames, Surrey, England
Sawhney, B., Associated Electrical Industries, Lahore, India
3 Foreign

# Engineering Literature

## New Books in the Societies Library

Among the new books received at the Engineering Societies Library, New York, during April are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no reponsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

S.A.E. HANDBOOK. Complete supplement to 1931 edition. N. Y., Society of Automotive Engrs., 1932. 125 p., illus., 7x4 in., paper, $1.00 to non-members; $.50 to members.—Instead of issuing a revised edition of the handbook, the Society has published this complete supplement. Containing all new and revised standards and recommended practises adopted since the last book appeared, with a list of canceled specifications, thus bringing the work entirely up to date.

SCHWEIZERISCHE ENERGIEWIRTSCHAFT. By M. L. Keller. Aarau (Switzerland), Verlag H. R. Sauerläander & Co., 1931. 112 p., 9x6 in., cloth, 4 Swiss Frs.—A discussion of electric power development in Switzerland, its defects, and ways to better conditions. Treated from economic and political points of view. Establishment of a special government institution is advocated, patterned on the Swiss National Bank, to which the control of power developments and electricity supplies will be delegated.

SYMPOSIUM ON EFFECT OF TEMPERATURE ON THE PROPERTIES OF METALS. Am. Soc. of Mech. Engrs., N. Y., and Am. Soc. for Test. Mtls., Phila., 1932. 829 p., illus., 9x6 in., cloth, $6.00 to non-members; $5.00 to members.—Papers (27) presented at a joint meeting of the A.S.M.E. and the A.S.T.M. in Chicago, 1931; discuss various problems related to engineering trends and requirements for metals at high and low temperatures, and the properties of metals for use at these temperatures. The book ably summarizes our present knowledge of the subject and brings up to date the records of a similar meeting in 1924. A bibliography is included.

TALKING PICTURES. By B. Brown. N. Y. & Lond., Isaac Pitman & Sons, 1931. 305 p., illus., 9x6 in., cloth, $3.00.—Origin, how it works, and the practical details of the apparatus and its operation for the modern talking picture as set forth in an interesting way in this book. Successful explanation of matters in a way can be understood without technical training, and in presenting a comprehensive view of the industry within a moderate compass.

THE TAYLOR SERIES, an introduction to the theory of functions of a complex variable. By P. Dienes. Oxford, Eng., Clarendon Press (gift of Oxford University Press, N. Y.), 1931. 552 p., 9x6 in., cloth, 30s. This scholarly introduction to the theory of functions of a complex variable adopts the way of approach by the methods of Cauchy and Weierstrass. The first seven chapters give the elements of the usual Cauchy-Weierstrass theory. The remaining seven chapters discuss and coordinate further developments of the theory by Picard, Hadamard, Mittag-Leffler, Borel, and others. There is a good bibliography.

WORKING FOR THE SOVIETS, an American Engineer in Russia. By W. A. Rukeyser. N. Y., Covici, Friede, 1932. 286 p., illus., 8x6 in., cloth, $3.00.—A first-hand description of industrial conditions, by an American mining engineer. The author's work for the Soviet government took him to the asbestos mines of western Siberia with no companions except Russians. He had unusual opportunities to know them and to learn what they thought and how they lived. He gives an interesting account of his experiences.

ADVANCING SCIENCE. By O. Lodge. N. Y., Harcourt, Brace & Co., 1932. 191 p., 8x5 in., cloth, $2.00.—This volume sketches the work of the British Association for the Advancement of Science between 1870, when Sir Oliver Lodge became a member, and 1900. A regular attendant at its annual meetings, he has vivid recollection of the great men of that period and of the outstanding events and papers of each meeting. These he describes in an interesting manner. The discovery of the electron and the beginnings of the study of ether waves are discussed.

AMERICAN ELECTRICIANS' HANDBOOK. By T. Croft. 3d ed., N. Y. & Lond., McGraw-Hill Book Co., 1932. 1051 p., 7x4 in., leath., $4.00.—This popular handbook gives the facts about apparatus, materials, installation, and operation needed by wiremen, contractors, linemen, plant superintendents, and construction engineers in their daily work. Theory is reduced to a minimum, but sufficient is given to explain the reasons for the methods recommended. The edition has been revised to conform with current practise and the latest code requirements.

BEHEMOTH, the Story of Power. By E. Hodgins and F. A. Magoun. Garden City, N. Y., Doubleday, Doran & Co., 1932. 354 p., illus., 9x6 in., cloth, $3.50.—A narrative history of power, built about personalities which have contributed to the evolution of motive machinery, and intended for the reader without technical training. The development of the steam and internal-combustion engines, of the dynamo and hydraulic turbine, is presented in broad outline from the earliest times to the present, in an unusually readable, entertaining way.

EINFÜHRUNG IN DER EBENE GETRIEBELEHRE. By T. Pöschl. Berlin, J. Springer, 1932. 127 p., 9x6 in., paper, 9.75 rm.—An elementary textbook, designed for home study and for students in engineering colleges. Graphic methods are used and a knowledge of vectorial analysis is required. The course is planned with close attention to practical needs.

HOCHFREQUENZTECHNIK IN DER LUFTFAHRT. By H. Fassbender. Berlin, J. Springer, 1932. 577 p., illus., 10x6 in., cloth, 68 rm.—Prepared for the German Aircraft Research Institute by a number of specialists, this book is intended to present a comprehensive account of the present state of radio communication with aircraft. The theoretical principles and methods of measurement first are considered; then the problems of direction finding. The apparatus used in the different flying countries is described, after which a section is devoted to radio service for flyers. Theoretical and practical aspects of the subject are discussed at some length, and bibliographies are scattered through.

ELEMENTS OF HUMAN ENGINEERING. By C. R. Gow, ed. by F. A. Magoun. N. Y., Macmillan Co., 1932. 169 p., 8x5 in., cloth, $1.60.—The second of a series of books by the professor of humanics at the Massachusetts Institute of Technology. From his broad practical experience, Professor Gow gives sensible advice to the young engineer who is beginning his career upon the cultivation of correct personal relations with superiors and subordinates and similar topics that greatly affect his success in life but are not covered in his course of study.

NACHTRAG III ZUM WERKSTOFFHANDBUCH NICHTEISENMETALLE. Berlin, Beuth-Verlag, 1932. 14 p., illus., 8x6 in., paper, 3.50 rm.—Third supplement to the Handbook of Non-Ferrous Metals. Contains new information upon torsion testing, corrosion testing, electric melting furnaces, metal coatings, and the working of pure aluminum. The material is in loose-leaf form for insertion in the handbook.

### Engineering Societies Library

29 West 39th Street, New York, N. Y.

MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

# Annual Technical Committee Reports to the Board of Directors

In accordance with Section 82 of the A.I.E.E. By-Laws, the Technical Committees of the Institute have prepared the following reports for presentation at the Summer Convention.

To accomplish a timely circulation of these committee reports throughout the membership of the Institute, ELECTRICAL ENGINEERING presents on the following 27 pages a preprint of a portion of a future issue of the quarterly TRANSACTIONS.

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# Research

## ANNUAL REPORT OF THE COMMITTEE ON RESEARCH[*]

DURING the year 1931 the Committee on Research has encouraged the presentation of research papers and has reviewed many for sessions on research before the A.I.E.E. On account of the broad field which must be covered by this committee it has been impracticable to organize subcommittees under any specific classification. The burden of reviewing papers has fallen to practically all members and excellent cooperation has been obtained by correspondence and without committee meetings.

The following topics are worthy of mention to show the progress that has been made during the year. The subjects reported have all been suggested by committee members.

### PHYSICS

Dr. R. J. Van de Graaf of Princeton University and Massachusetts Institute of Technology has developed static machines of a very simple construction using endless silk belts with which he has generated as high as 1,500 kv. This work is being extended to much higher voltages.

Dr. F. Lange and A. Brasch of the University of Berlin have built a simple X-ray tube consisting of alternate rings of paper, rubber, and aluminum which they hope to operate with voltages up to 2,500 kv.

A number of developments have taken place during the year in connection with X-ray tubes and auxiliaries. Some of these are described in the January issue of the *General Electric Review*. The application of X-rays commercially has been extended during the year to the sterilization of food and food products.

Experiments have recently been made in this country on a sodium vapor lamp, originally developed in Germany. This lamp has been made possible by a new kind of glass which is not blackened by the sodium vapor. This lamp is said to be several times as efficient as the ordinary mercury or gas filled lamp.

In ferro-magnetic materials changes in magnetization do not occur instantaneously throughout the mass of the material, but start locally and are propagated with finite velocity. This was demonstrated on a large scale by K. F. Sixtus and L. Tonks and the velocity of propagation was measured in nickel-iron wires under tension. (*Physical Review*, 37, 1930, p. 1958, April 1931.)

From the Westinghouse Laboratories a new magnetic phenomenon has been reported by F. Bitter, which consists in the discovery of magnetic inhomogeneities of a definite and regular pattern in the individual crystals of ferro-magnetic materials. These are of quite a different nature, depending on the type of material. No satisfactory explanation has yet been obtained for this phenomenon.

Members of the staff of the Alabama Polytechnic Institute have announced the discovery of the last missing element No. 85.

From theoretical considerations, it was believed that atoms of hydrogen might exist which are twice as heavy as the ordinary atoms. These have now been discovered experimentally by H. C. Urey and G. M. Murphy of Columbia University and F. G. Brickweede of the Bureau of Standards.

Walter Bathe is reported by A. H. Compton to have produced gamma rays by bombarding beryllium metal with alpha rays. His experiments indicate a possible synthesis in which a heavier element, carbon, is formed and if proved correct it may greatly affect all ideas of how the solar system and our earth originated. (*Sc. News Letter*, p. 223, Nov. 21, 1931.)

Vacuum tubes are continually extending the ranges of possible electrical measurements and thereby opening new fields of physical research. L. A. DuBridge (*Physical Review*, 37, page 392, 1931) reports measurements of small currents of the order of $10^{-18}$ amperes which corresponds to six electrons per second.

Fowler (*Physical Review*, Vol. 38, page 45, 1931) has made important theoretical investigations of the photoelectric threshold values of clean metals at various temperatures.

Newton Harvey (*Jl. of General Physiology*, Vol. 15, p. 147) has demonstrated that living cells are disintegrated by ultra-sonic waves in less than $^1/_{1000}$ of a second.

R. W. G. Wyckoff (*Radiology*, Vol. 17, p. 1171, 1931) has obtained important data on the destruction of micro-organisms by X-rays and cathode rays in continuation of his previous work in this field.

Boer and Teves (*Zeitsch f. Phys.*, Vol. 73, page 192, 1931) have obtained further important results in connection with their investigation of the photoelectric properties of caesium oxide films in conjunction with halide salt layers.

Bergmann (*Zeitsch. f. Phys.*, April 1, 1931) has described an important photoelectric cell involving essentially the photoelectric properties of iron selenide.

### DIELECTRICS

The Committee on Electrical Insulation of the Division of Engineering and Industrial Research of the National Research Council reports very substantial progress in the study of dielectrics and dielectric phenomena. Its report, which summarizes a considerable number of recently presented papers, should be consulted by those interested in this subject. The following items, some of which were reported by the National Research Council, are of particular interest. Some of these results have been presented in the form of papers before the Institute.

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[*] COMMITTEE ON RESEARCH:

L. W. Chubb, Chairman,
H. D. Arnold,
Edward Bennett,
W. G. Cady,
E. H. Colpitts,
E. C. Crittenden,
W. F. Davidson,
W. P. Dobson,
F. M. Farmer,
V. Karapetoff,
A. E. Kennelly,
J. K. McNeely,
F. W. Peek, Jr.,
H. H. Race,
C. W. Rice,
D. W. Roper,
T. Spooner,
J. B. Whitehead,
R. J. Wiseman.

A further reference which may be consulted with profit to those interested is monograph No. 5 of the American Chemical Society, by Professor C. P. Smythe of Princeton University, giving an extensive summary of the results of the work in determining molecular structure.

The following four A.I.E.E. papers from The Johns Hopkins University on this subject by Dr. Whitehead and his associates are particularly valuable, namely, on the *Conductivity of Insulating Oils, The Fundamental Properties of Impregnated Paper, Residual Air and Moisture in Impregnated Paper,* and *The Predetermination of the A-C. Characteristics of Dielectrics.* Other valuable A.I.E.E. papers on dielectrics are *Insulation Variability,* by M. C. Holmes; *On the Theory of Thermal Breakdown of Solid Dielectrics* by P. H. Moon, and another in the same field by Kenney, Luery, and Moriarty.

In one of the above mentioned papers by Whitehead and Banos there is announced a most remarkable agreement between loss, power factor, and capacity values at 60 cycles for solid and liquid dielectrics as determined experimentally and as calculated from the d-c. characteristics as obtained by the oscillograph.

By very careful distillation and purification as reported by L. A. Welo it has been possible to produce insulating oils having conductivities of $10^{-18}$ to $10^{-19}$ ohms.

The Bell Telephone Laboratories have reported very interesting results on ordinary insulation in which they point out that it is the metallic salt content of considerable solubility in water which controls the insulation or conductivity characteristics of such materials. Washing with water improves the insulation properties decidedly and improvement can be obtained by replacing the soluble salts with more insoluble salts by chemical reaction.

Work continues in an increased amount on the subject of polar molecules in dielectrics. This subject, originally considered of no practical value, is now being studied for viscous liquids and even solids, with very important results. Development of polar molecules in insulating oils gives a measure of deterioration. The work of W. N. Stoops points out the very definite correlation and the fact that the measure of the polar characteristics under accelerated test may furnish a measure of the useful life of an oil.

Dielectric losses in highly refined insulating oils at commercial frequencies and operating temperatures have been shown to result from conduction, but at high frequencies and low temperatures the major loss may be accounted for by the orientation of polar molecules. (H. H. Race, *Physical Review,* 37, p. 430–436, Feb. 1931.)

At Johns Hopkins University and the Bell Telephone Laboratories further studies on abietic acid and rosin have been made as to the part played by dipoles in the s.i.c. and loss characteristics of material over ranges of temperature and frequency. This type of work, directed toward an understanding of the mechanism of the dielectric in detail, is most important. It is interesting to note that both sets of data can be explained by the generalized theories of Schweidler and Wagner, which consider the dielectric mass as a whole, or by the dipole theory of Debye, which considers the microscopic structure, namely, the individual atoms, molecules, or ions as dipoles.

Studies of cable oil and cable conditions at a number of laboratories were reported last year, particularly on the effect of ion bombardment on oils. The necessity for a completely filled, solid, compact cable to prevent internal ionization is further shown. For example, it has been shown by the Detroit Edison Company that the power factor of an oil is directly correlated with the amount of hydrogen freed by ion bombardment. In the studies of the fundamental properties of paper, oil, and impregnated paper at Johns Hopkins University, it was found that with high grade oil the larger portion of the dielectric loss was attributable to the paper. Further, it has been shown by the Commonwealth Edison Company that tackiness of adhesion of the compound is correlated with long life of cables.

J. A. Scott of the General Electric Company has shown that oil pressures of several atmospheres applied to impregnated paper insulated cable give a decided increase in the life of the cable as measured by an endurance test.

The increased use of the oil filled type of cable and the growing use of oil for filling joints in ordinary impregnated paper insulated cable have greatly increased the importance of the integrity of the lead sheath. Several research projects dealing with lead are in progress. Work at the University of Illinois has shown that the creep of lead and several common lead alloys occurs at stresses below 200 lb. per square inch; that is, at stresses which may occur in cable sheaths during normal operation.

Researches on transmission cables show a tendency to depend on accelerated aging tests as a measure of the life quality. Both utilities and cable manufacturers are conducting researches on long lengths of impregnated paper-insulated cable to duplicate in a short time what takes place over a period of years in service. The present indications are that, by subjecting the cable to about 2.5 times normal voltage, and at the same time superposing loading cycles resulting in a maximum temperature somewhat above the limiting temperature for the cable, and by making measurements of power factor and ionization factor at suitable intervals throughout a test continuing a week or two, it is possible to predict the effect of many years of normal service on the stability of insulation.

Considerable interest is taking place as to the influence of pressure on a cable and its relationship to the migration of the oil in the cable as it goes through its temperature cycle.

The Detroit Edison Research Department reports that chemical reactions of organic compounds in electrical discharges are being studied as a part of a program of investigation of the deterioration of oil-impregnated paper insulation of high-tension cables. The results of an experimental survey covering 57 different hydrocarbons has been published (*Jour. Phys. Chem.*, 35, 3649 (1931)).

In the field of insulation, J. B. Whitehead summarizes the accomplishments for the year as follows:

This research has been characterized by a definite extension of our knowledge of the behavior of insulating liquids and its causes. This is a result largely of the development of amplifier and oscillograph methods for measuring short-time behavior of liquids when used for the impregnation of paper with the result that a much closer insight is now possible as to the origin of the properties of high-voltage impregnated paper insulation. A continuation of the accelerated life studies on laboratory samples of impregnated paper is clearing up the uncertainties heretofore existing as to the relative importance of residual air and moisture in impregnated paper. In connection with these researches, an important method of analysis of the results of a-c. measurements has been developed and its limitations explored.

### CIRCUIT INTERRUPTION

Vacuum relays developed in Germany have been introduced into this country which make use of the flexibility of glass to transmit sufficient motion to operate contacts. This is possible because of the very small contact separation necessary in a vacuum.

Slepian and Strom in an Institute paper (ELECTRICAL ENGINEERING, Dec. 1931) have given a valuable analysis of the factors which govern arc extinction in low-voltage network cables. It is shown that the gas blast, as the result of the action of the arc on cable insulating materials, is largely responsible for the clearing of faults. Data are given on the extinguishing characteristics of various types of chemical compounds.

By intensive research, the possibilities of boric acid in connection with circuit interrupting devices have been developed to a point where commercial applications are in sight. The production of water vapor from the boric acid by the action of the arc causes a powerful deionizing action. The water vapor may be condensed, thus making possible a very efficient enclosed fuse for high interrupting capacities.

### MISCELLANEOUS

H. B. Dwight has given a very useful analysis of the proximity effects in cable sheaths (A.I.E.E. TRANSACTIONS for September). This is supplementary to the formulas published by him some years ago in the *Electric Journal*.

In the same issue of the TRANSACTIONS there is a group of papers on the measurement and analysis of noise in electrical machinery which, in some aspects represents contribution of new knowledge as the direct result of careful research. The science of acoustics is becoming an important phase of electrical engineering. Since the world has become noise conscious the elimination of unnecessary noises will be only a matter of time. Some of the new portable noise analyzers which have been placed on the market this last year make the measurement of the magnitude and the analysis of noises much easier.

By studies at the Westinghouse Laboratories, of car and train models in wind tunnels, fundamental data have been obtained on the advantages of streamlining. These results will be of great value in reducing power and making possible high-speed land transportation.

R. M. Baker has discovered that the presence of small quantities of mercury vapor in a non-oxidizing atmosphere very greatly reduces the contact resistance for certain types of brushes and slip rings. This may be of some commercial value, especially where it is wished to use very high current densities. (*Elec. Journal*, February 1932).

The development of the helical groove on slip rings and commutators by G. M. Little promises to be of considerable value in connection with the problem of current collection and commutation. Field tests have shown decided improvements in brush wear, sparking and distribution of current between parallel brushes (ELECTRICAL ENGINEERING, June 1931, p. 427).

Researches on the conditions desirable for the greatest human comfort, namely, the effect of humidity, wall temperature, air flow, and ionic condition of the air, etc., have been very active during the past year. Also the usefulness of reversed refrigeration for the heating of houses and buildings is being tried out commercially in several installations. Air conditioning is apparently to become soon a very considerable industry of great importance to the electrical interests.

Very sensitive research measurements have shown that all metals flow to some extent at high temperatures and that this flow can be reduced by using proper heat treatment of certain alloys. Such studies are used as a basis for new mechanical design of high temperature steam and electrical turbines so that proper clearance will be maintained throughout long life. (Paper presented by F. P. Coffin and T. H. Swisher at the National Applied Mechanics Meeting of the American Society of Mechanical Engineers, June 15, 1931.)

In the field of radio, Bruce's work on directive short wave antennas is of importance.

There are two recent developments in piezo-electricity worthy of note. Thin plates of tourmalin have, within recent months, shown themselves to be excellent piezo-oscillators, particularly for very short waves down to about two meters wavelength. An interesting circumstance in this connection is that, although tourmalin was one of the very first piezo-electric crystals to be studied, nevertheless the practical applications are of very recent date. Another recent application of piezo-electric crystals is their use in filter circuits of very high selectivity.

The researches on the fundamental electrical units which have been under way at the Bureau of Standards for several years have reached a stage such that preliminary values can be given, subject to some minor corrections. The results confirm earlier determinations in showing that the international ohm is 5 parts in 10,000 larger than it should be, while the ampere has very nearly the correct value as determined by measurement of mechanical forces between coils. Comparisons of fundamental standards in recent years have shown differences between the standards of different countries large enough to be troublesome in precise scientific work. Direct comparisons between silver voltameters of the Bureau of Standards, the British National Physical Laboratory and the German Physikalisch-Technische Reichsanstalt were made during the year at Berlin; these proved that existing discrepancies arose in large part from changes in the German standard cells. Several years ago the International Committee on Weights and Measures decided that eventually the electrical units should be based upon absolute (mechanical) measurements rather than upon standards arbitrarily defined. The International Committee meets in 1933, and it is hoped that definite plans can then be approved for introducing electrical units on the new basis, assuring international uniformity of values, and removing the discrepancy between electrical and mechanical units.

# Electrical Machinery

## ANNUAL REPORT OF THE COMMITTEE ON ELECTRICAL MACHINERY*

### Activities of the Committee

THE committee during the year has reviewed approximately 50 papers, of which 24 have actually been accepted and published. Work on the preparation of test codes has been carried on during the year, and the Transformer Test Code was published in preliminary form in October. Favorable comments have been received on this, and work on the test codes for induction machines, synchronous machines, and d-c. machines is now approaching completion.

While direct responsibility of the machinery committee for standards, except for transformers, has now been transferred to the Sectional Committee of the A.S.A., the machinery committee has participated indirectly in the revision of the rotating machinery standards, and in particular has sponsored proposals to determine accurate efficiencies of induction and direct-current motors. Mr. C. J. Koch's paper on *Measurement of Stray Load Loss in Polyphase Induction Motors*, presented at the Providence Meeting of the Institute in May 1932, is an important contribution in this field.

The transformer subcommittee has been very active in revising the Transformer Standards No. 13, and it is now undertaking the very important task of standardizing impulse voltage tests.

Revisions in the standards for constant-current transformers and in the Standards Report on Capacitors have also been prepared.

### Synchronous Machines

One of the 200,000-kva., 0.8-power factor, 1800-r.p.m. steam turbine-driven alternators (GE)[1] in the Brooklyn Edison Company's plant has been operated successfully at its rated kilowatt output, and the second unit is being installed. A 121,000-kva., 18,000-volt, 1,800-r.p.m. (AC) unit was placed in operation at Waukegan, and a 147,000-kva., 22,000-volt unit (AC) for the State Line Station is under construction. A 25,000-kva., 13,800-volt, 3,600-r.p.m. machine (W) was shipped to the Public Service Electric and Gas Company and is the largest unit yet undertaken at this speed. A 99,000-kva., 13,800-volt, 1,800-r.p.m. generator (W) is under construction for this company and is the largest unit so far built with internal fans.

Five vertical-shaft waterwheel-driven alternators rated at 48,500 kva., 13,800 volts, 25 cycles, 750 r.p.m. (CGE) are under construction for the Abitibi Cangon Development near James Bay.

A 1,250-kva., 960-cycle, single-phase generator (GE); a 1,250-kva., 1,000-cycle, single-phase generator (GE); and a 3,000-kva., 420-cycle, single-phase generator (GE) represent increases in capacity over high-frequency machines of this type built before the year 1931.

A 75,000-kva., 12,600-volt, 514-r.p.m., synchronous condenser (W) is under construction for the Commonwealth Edison Company. This is an increase of fifty per cent over the previous largest synchronous condenser.

During the year there has been considerable activity in the development of designs to improve the starting performance of industrial synchronous motors, particularly as to higher torque per kva. inrush. Several motors of 200 to 600 hp. at 300 to 900 r.p.m. have been built with a starting torque efficiency (per cent starting torque over per cent kva. inrush or unity power factor base) of the order of 55 per cent.

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* **COMMITTEE ON ELECTRICAL MACHINERY:**

**P. L. Alger, Chairman, General Electric Co., Schenectady, N. Y.,**
**B. L. Barns,**
**E. S. Bundy,**
**H. E. Edgerton,**
**J. E. Goodale,**
**T. T. Hambleton,**
**A. L. Harding,**
**C. F. Harding,**
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**K. A. Reed,**
**A. M. Rossman,**
**O. E. Shirley,**
**R. G. Warner,**
**C. A. M. Weber,**
**R. B. Williamson.**

[1] **Manufacturer Designation:**
**AC—Allis-Chalmers Manufacturing Company**
**BB—American Brown Boveri Company**
**CGE—Canadian General Electric Company**
**CW—Canadian Westinghouse Co., Ltd.**
**ED—Electric Dynamic Company**
**EM—Electric Machinery Manufacturing Company**
**GE—General Electric Company**
**W—Westinghouse Electric & Manufacturing Company**

Two motors for pulp grinder drive (EM) will use stator windings in four parallels, and these motors will be started by applying successively the parallel circuits all on the reduced voltage of the autotransformer. These suitably timed increments will reduce the kva. inrush to a minimum.

The twelve 5,500-hp. motors (GE) for the U. S. Mail S.S. Company have been completed, and two ships with two motors each are in service.

The S.S. *President Hoover* (GE) and the S.S. *President Coolidge* (W) each with two 13,250-hp. motors were placed in service during the year.

Two 30,000-kilowatt frequency changers (GE) with generators rated 42,860 kva., 0.70 power factor, single-phase, 25 cycles, and motors rated 36,000 kva., 0.9 power factor, three-phase, 60 cycles, and operating at 300 r.p.m. are being installed at the Richmond Station of the Philadelphia Electric to supply power to the Pennsylvania Railroad electrification. These sets have twice the capacity of single-phase sets previously built. The generators are equivalent mechanically to 61,000-kva., three-phase machines. The frequency changers are designed for outdoor operation in steel enclosing housings.

## INDUCTION MACHINES

There has been considerable activity during the last year in induction machines. The demand for squirrel-cage motors for rapid and oft-repeated reversing duty, of a nature heretofore confined to d-c. mill type motors, has led to the development of special motors with low inertia rotors and liberal radiating surfaces. This demand came chiefly from the steel mill industry and concerned motors for use on furnace conveyers of the "stroke" type and motors for newly developed automatic sheet handling apparatus as used for hot finishing mills. The simple squirrel-cage motor, while it has some disadvantages as regards disposition of loss, nevertheless offers many advantages for this type of service, *e. g.*, a low-inertia, sturdy, dependable, simple, rotating element, simplified control; faster-operating control; lower-cost motor and lower-cost control. The opening up of this field to squirrel-cage motors will undoubtedly add to the wider application of this type of motor.

The use of totally enclosed fan-cooled motors has increased enormously. One company reports that over half of its induction motor production for last year was of the fan-cooled type. This type of motor is available in mounting dimensions the same as those for open motors of equal rating up to fairly large sizes, and has been well received by the trade where open type motors were subject to aggravated dirt conditions.

Selsyn motors as mediums of control formed a successful means of maintaining levels on both ends of a lift bridge on the Missouri, Kansas, Texas Ry. Other novel applications of this type of motor as a control or as an indicator are under way.

Induction frequency converters of the commutator type have, during the year, been built for use at frequencies as low as $2^1/_2$ cycles. Machines of this type with outputs at ten cycles have been supplied by a large manufacturer to increase the range of his slip-ring frequency converters. These latter, driven by a d-c. adjustable-speed motor, have a normal range of 120 to 180 cycles. By supplying 10 cycles to these converters at approximately $^1/_6$ normal voltage, the frequency range of these converters became 70 to 130 cycles, and a range of 70 to 180 cycles was made possible. These latter frequencies were used to supply small high-speed squirrel-cage motors and give them adjustable-speed characteristics for improvement in manufactured product.

## DIRECT-CURRENT MACHINES

A triple unit motor has been built (ED) for ship propulsion. One auxiliary and two main motors are placed in line with their armatures on one shaft. The auxiliary motor is designed for low cruising speed with higher efficiency than could be obtained in the main motors at low speed.

Two 2,500-hp., 282/708-r.p.m., constant-torque, induction motors have been built (AC) for driving reciprocating, 1,500-lb. per sq. in., boiler feed pumps. The Rossman system of varying speed is used. This is the first case where the d-c. armature has been mounted directly on the rotatable induction motor primary.

A 12,500-hp., 44-inch, slabbing mill drive (W) has been placed in operation. Each main roll is separately driven, without pinions, by a 5,000-hp. double-unit motor; the edging rolls by a 2,500-hp. single motor. Power is supplied by a 10,500-kw., 700-volt, d-c. set composed of one induction motor, 180,000-lb. flywheel, and three 3,500-kw. generators.

A roll grinder has been equipped (W) with nine d-c. motors for controlling separately every motion and adjustment.

## TRANSFORMERS

Manufacturers have given increased attention to the design of both power and distribution transformers to better withstand lightning surges and to developing methods of impulse testing to indicate weakness in transformer insulation to such surges.

Several large shell-type surge-proof power transformers (W) of the new type were built, among them units of 42,000 kva., 220 kv. which were subjected to unusually severe impulse tests, 4,500-kva. units for the Pennsylvania Railroad and a 70,000-kva. unit for the United Electric Light and Power Company, which is thought to be the largest of the self-cooled type in this country.

Self-contained features for protection against lightning independently of transformer connections or grounding practise, and for prevention of outages, were accomplished by incorporating high-voltage deion gaps and coordinated low-voltage bushings in standard distribution transformers (W).

Cover-roof type bushings are a feature of a new line of distribution transformers (AC) intended particularly for service on rural lines.

Two transformers (GE) of new design were fur-

**Table I. Mercury Arc Rectifier Units Placed in Operation During 1931 or on Order December 31, 1931**

| Purchaser | No. of Sets | D-c. Volts | Kilowatts per Set | Total Kilowatts | Type of Control | Service | Placed in Service | Manufacturer |
|---|---|---|---|---|---|---|---|---|
| Amer. Gas & Elec. Co., New York | 2 | 610 | 500 | 1,000 | Automatic | Railway | 1931 | BB |
| Boston Elevated Railway | 2 | 600 | 3,000 | 6,000 | Automatic Remote Control | Railway | 1931 | GE |
| Cleveland Railway Company | x1 | 600 | 500 | 500 | Semi-Automatic | Railway | 1931 | W |
| Clinton, Davenport & Muscatine Rwy | 1* | 700 | 500 | 500* | Automatic | Railway | 1931 | BB |
| Commonwealth Edison Co. | 3 | 625 | 3,125 | 9,375 | Manual | Railway | 1931 | BB |
| Commonwealth Edison Co. | 1 | 625 | 2,080 | 2,080 | Automatic | Railway | 1931 | BB |
| Commonwealth Edison Co. | 1 | 625 | 3,125 | 3,125 | Automatic | Railway | 1931 | BB |
| Commonwealth Edison Co. | 1 | 625 | 3,125 | 3,125 | Manual | Railway | 1931 | GE |
| Commonwealth Edison Co. | 1 | 625 | 3,125 | 3,125 | Manual | Railway | 1931 | GE |
| Commonwealth Edison Co. | 1 | 625 | 3,125 | 3,125 | Manual | Railway | 1931 | GE |
| Consol. Mining & Smelting Co. of Can. | 1 | 650 | 6,500 | 6,500 | Manual | Electrolytic | 1931 | GE |
| Consol. Mining & Smelting Co. of Can. | 2 | 650 | 6,500 | 13,000 | Manual | Electrolytic | 1931 | BB |
| Detroit, City of | 1 | 600 | 2,000 | 2,000 | Automatic | Railway | 1931 | GE |
| I. G. Farbenindustrie for Standard Oil Co. of Louisiana | °1 | 3,500/9,600 | 2,200 | 2,200 | Manual | Electrochemical | Being erected | BB |
| Illinois Power & Light Company | 1 | 650 | 540 | 540 | Automatic | Railway | 1931 | W |
| Indiana Railroad Company | 2 | 625 | 850 | 1,700 | Manual | Railway | 1931 | BB |
| Long Island Railroad Company | x1 | 650 | 3,000 | 3,000 | Automatic Remote Control | Railway | 1931 | W |
| Long Island Railroad Company | 5 | 650 | 3,000 | 15,000 | Automatic | Railway | 1931 | BB |
| Long Island Railroad Company | 4 | 650 | 3,000 | 12,000 | Automatic | Railway | On order | AC |
| Los Angeles Railway Corporation | 2 | 600 | 1,500 | 3,000 | Automatic Remote Control | Railway | 1931 | GE |
| Louisville Gas & Electric Co. | 2 | 600 | 1,000 | 2,000 | Automatic | Railway | 1931 | GE |
| Montreal Tramways Company | 2 | 600 | 1,500 | 3,000 | Automatic Remote Control | Railway | 1931 | GE |
| Mason City & Clear Lake Railway | 1* | 650 | 500 | 500* | Automatic | Railway | 1931 | BB |
| N. Y. Board of Transportation | 10 | 625 | 3,000 | 30,000 | Automatic Remote Control | Subway | 1931 | GE |
| N. Y. Board of Transportation | 13 | 625 | 3,000 | 39,000 | Automatic Remote Control | Subway | Being erected | GE |
| N. Y. Board of Transportation | 15 | 625 | 3,000 | 45,000 | Automatic Remote Control | Subway | On order | GE |
| N. Y. Board of Transportation | 13 | 625 | 3,000 | 39,000 | Automatic Remote Control | Subway | On order | GE |
| N. Y. Central R.R. Company | 1 | 666 | 3,000 | 3,000 | Automatic Remote Control | R.R. Electrif'n | 1931 | GE |
| Northern Indiana Pub. Service Co. | 1 | 1,500 | 3,000 | 3,000 | Automatic | Railway | 1931 | BB |
| Paris Orleans Rwy.—France | 1 | 1,500 | 1,500 | 1,500 | Automatic | R.R. Electrif'n | 1931 | GE |
| Philadelphia, City of | 2 | 630 | 3,150 | 6,300 | Manual | Railway | On order | AC |
| Piedmont & Northern Railway | 1 | 1,500 | 750 | 750 | Automatic | R.R. Electrif'n | 1931 | W |
| Quebec Power Company | 1 | 550 | 1,200 | 1,200 | Automatic | Railway | 1931 | BB |
| Regina, City of | 1 | 575 | 1,200 | 1,200 | Manual | Railway | 1931 | BB |
| Sun Life Assurance Co. of Canada | 2 | 250 | 400 | 800 | Manual | Power | 1931 | BB |
| Trenton Transit Company | 3 | 600 | 1,400 | 4,200 | Manual | Railway | 1931 | BB |

* In addition, one spare rectifier (without transformer) was supplied.
x Temporary installation.
° Also reported 1930.

**Totals***

| | 1931 | | 1930 | |
|---|---|---|---|---|
| | No. of Sets | Kilowatts | No. of Sets | Kilowatts |
| Placed in service | 57 | 127,845 | 33 | 75,225 |
| Being installed | 14 | 41,200 | 26 | 71,400 |
| On order | 34 | 102,300 | 29 | 79,275 |
| Grand total for year | 105 | 271,345 | 88 | 225,900 |
| Total number units in service, Dec. 31st | 180 | 305,379 | 123 | 177,534 |

* Spare rectifier tanks without transformers not included.

nished to operate an X-ray tube for cancer research in the California Institute of Technology. Each unit is rated 0.03 ampere at 700,000 volts to ground continuously, and operates in series with mid-point grounded, giving 1,400,000 volts effective at the X-ray tube.

Magnetic oil level indicators were made available (GE and AC) for power, large distribution, and high-voltage instrument transformers. This gage has numerous advantages over a glass oil gage because it is more easily read, and more easily maintained oil tight. It has no glass to become dirty on the inside or break and allow oil to run out.

The number and capacity of load-ratio control transformers exceeded all previous records. The development of a design (GE) suitable for lower-rated circuits up to 15,000 volts, single-phase or three-phase, resulted in an economical application of load-ratio control to distribution transformer sizes. This type of equipment was applied to the new three-phase 1,500-kva. transformers for high-voltage networks. A new line of standard tap changers (W) using standard parts suitable for wide range of capacities as low as 200 kva. were completed.

A new type of inertaire protection for power transformers (W) using nitrogen from a gas cylinder was perfected. A uni-directional breather (AC) for use on power transformers, which induces a natural circulation of air over the oil in the main transformer tank or expansion tank to reduce condensation and carry off condensed moisture was developed.

## MERCURY-ARC RECTIFIERS

The use of rectifiers has continued to expand during the year as indicated by information contained in Table I.

The large number of additional 3,000-kw. 625-volt units ordered by the New York Board of Transportation is the outstanding feature of this year. Twenty-three of these rectifiers were ordered last year and 28 this year, making a total of 51 sets (GE) with a total capacity of 151,000 kw.

The three 6500-kw. 650-volt electrolytic rectifiers listed in this and last year's report were placed in service during the year.

A 3,000-kw. 650-volt sectional rectifier (W), consisting of four 750-kw. separate rectifiers arranged in a compact unit, was developed and placed in service.

The first complete portable mercury-arc rectifier substation, consisting of a 540-kw., 650-volt (W) rectifier with transformer and control, cooling system, car, etc., was placed in service by the Illinois Power & Light Company.

# Protective Devices

## ANNUAL REPORT OF THE COMMITTEE ON PROTECTIVE DEVICES*

THE work of the Committee on Protective Devices during the past year was handled largely through subcommittees as has been the practise for several years. These subcommittees are listed below together with their chairmen:

| | |
|---|---|
| Relays | O. C. Traver |
| Oil Circuit Breakers, Switches, and Fuses | T. G. LeClair[1] |
| Lightning Arresters | H. K. Sels |
| Fault Current Limiting Devices | R. T. Henry |
| Interconnections[2] | F. C. Hanker |

### GENERAL

The committee continued its activities in following the preparation of standards, and review of research and development, although the main activity during the year was fostering the preparation and presentation of papers before the Institute.

While the technical achievement during the year is very satisfactory in view of the general business conditions, these conditions of course had a depressing effect on research and developmental activities. Progress in this respect consisted largely of refinements and extensions of fundamentals previously established.

Difficulty in securing agreement relative to certain matters concerning the standards for fuses and the revised standards for disconnecting, horn-gap and knife switches has prevented completing these standards. Plans have been made for a course of action which it is believed will permit of putting these standards into report form. Every effort is being made to place these standards in such shape that complete agreement may be secured which will permit their adoption as Institute Standards.

### RELAYS

#### *Report of Subcommittee*

The development of high-speed relays continued, resulting in marked improvements to primary power-system relays generally, and in new developments in the a-c. railway and secondary distribution network system fields.

One of the manufacturers has developed so-called straight-line relays, particularly for application on 4,000-volt networks which are capable of discriminating and operating on very small differences in current, although these currents may be quite heavy.

An important advance during the year was the redesign of all types of relays by at least one manufacturer in order to accommodate the relays in a new universal case, with standard stud arrangement, which is being used to a large extent for front of panel switchboard devices.

A high-speed current differential relay for transformer protection having an operating speed of 0.004 second has been developed.

Numerous refinements in mechanical details contributing to the reliability and accuracy of relays of all types have been carried forward.

Completed developments in coupling and protective equipment for all carrier-current applications include cable-type coupling-capacitor assemblies for all voltages from 115 to 230 kv., inclusive.

In order to secure a consensus of present day practise in regard to protection of apparatus of all classes, a questionnaire on this subject has been sent to a number of engineers, and a number of replies has already been received.

An important advance in relay application during the past year has been the wide increase in the use of the method of symmetrical components for determination of not only the fault current but also the voltage and current at the relay location, particularly for distance relay applications.

The following papers appearing under the auspices of the committee have been presented before the Institute:

*A New High-Speed Distance Relay,* S. L. Goldsborough and W. A. Lewis, Westinghouse Electric & Manufacturing Co.

*Application of High-Speed Relays,* G. W. Gerrell, Union Electric Light & Power Co.

*A New High-Speed Distance Relay,* A. R. Van C. Warrington, General Electric Co.

*Relay Operation From Bushing Potential Devices,* P. O. Langguth, Westinghouse Electric & Manufacturing Co., and V. B. Jones.

*Operation of Relays From Carrier-Current Coupling Capacitors and Capacitance Transformer Bushings,* J. E. Clem and R. E. Cordray, General Electric Co.

*Effect of Wave Form on Operation of Induction Relays,* P. H. Robinson, Houston Lighting & Power Co.

*A Telegraphic Pilot-Wire Relay System,* C. H. Frier, Oklahoma Gas & Electric Co.

### OIL CIRCUIT BREAKERS, SWITCHES, AND FUSES

#### *Report of Subcommittee*

Intense interest has been shown during the year in the fundamental theories underlying the various circuit breaker developments of the last few years. These discussions have resulted in clarifying conceptions of the theories on which these new types of breakers operate and has laid ground work for further development in the future. The amount of fundamental development which this intensive scrutiny reveals will, if supported by satisfactory performance records, do much to increase the confidence of the user in the ability of oil circuit breakers to perform adequately.

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* **COMMITTEE ON PROTECTIVE DEVICES:**

Raymond Bailey, Chairman,
L. F. Hickernell, Vice-chairman,
H. W. Collins,
A. W. Copley,
W. S. Edsall,
L. E. Frost,
S. L. Goldsborough,
R. T. Henry,
E. A. Hester,
T. G. LeClair
J. B. MacNeill,
J. P. McKearin,
H. A. McLaughlin,
D. M. Petty,
H. J. Scholz,
H. K. Sels,
H. P. Sleeper,
L. G. Smith,
E. R. Stauffacher,
H. R. Summerhayes,
O. C. Traver,
E. M. Wood,
H. B. Wood.

[1] Mr. LeClair was appointed chairman of the subcommittee on oil circuit breakers, switches, and fuses on January 4, 1932, when Mr. Hickernell resigned as chairman of this subcommittee.

[2] The interconnections subcommittee is a joint subcommittee having representation from the following committees: Protective Devices, Power Generation, Transmission and Distribution, Electric Machinery.

The metal-clad switchgear has been improved in a number of details and the development has been extended to interrupting ratings of 500,000 kva. at 15 kv. for indoor breakers and to 1,500,000 kva. at 132 kv. for outdoor breakers.

The oil-blast and deion grid principles of breaker construction were extended to quite high ratings, and both types have appeared in the metal-clad construction. Elaborate tests on a 1,500-ampere 15-kv. high-speed deion circuit breaker were performed for a railway application. Seventy-two short circuits ranging from 2,720 amperes to 50,500 amperes were thrown on the breaker in about five hours time. Some of these short circuits lasted only 0.024 second and the duration of the longer ones was 0.04 second. A series of fifty tests at current values from 11,000 to 49,000 amperes was run on impulse type of oil-blast breaker of a corresponding rating. This breaker clears the circuit in 0.04 second or less over the full current range.

Developments in air circuit breakers include extension of current ratings and improvements in operating speed.

The fuse manufacturers have been active in the development of improved type fuses, which are more economical.

There is a fairly widespread feeling among operating engineers in particular that some improvement could be made on the basis of rating of oil circuit breakers.

The following papers appeared under the auspices of the committee and have been presented before the Institute:

*The Theory of Oil-Blast Circuit Breakers*, D. C. Prince, General Electric Co.

*The Practical Application of the Oil-Blast Principle of Circuit Interruption*, R. M. Spurck, General Electric Co.

*Recent Developments in Arc Rupturing Devices*, R. C. Van Sickle and W. M. Leeds, Westinghouse Electric & Manufacturing Co.

*The Extinction of Alternating Current Arcs in Turbulent Gases*, T. E. Browne, Jr., Westinghouse Electric & Manufacturing Co.

*Application of Primary Distribution Fuses*, F. E. Sanford, Union Gas & Electric Company.

*The Expulsion Fuse*, J. Slepian and C. L. Denault, Westinghouse Electric & Manufacturing Co.

*Fuse Cut-Outs—Their Design and Application for A-C. Distribution Circuits*, E. G. Newton, General Electric Co.

*The Boric Acid Fuse*, A. P. Strom and H. L. Rawlins, Westinghouse Electric & Manufacturing Co.

## FAULT CURRENT LIMITING DEVICES

### *Report of Subcommittee*

The committee is not aware of any developments relating to fault current limiting devices of sufficient importance to warrant including in this report. Operating experience with such devices apparently continues to be quite satisfactory, and the need for further development is therefore not particularly urgent.

## LIGHTNING ARRESTERS

### *Report of Subcommittee*

As in other lines, the developments on lightning arresters consist principally of extensions of recently developed, fundamental theories to a greater variety of forms of station and line type arresters; also, a marked improvement has been made in the mechanical design and construction of lightning arresters which will improve the maintenance of their electrical characteristics.

Studies of lightning and the effects of lightning on power systems were continued during the year with considerable improvement in the technic of fault location. Newly developed lightning current meters and special low resistors were used to measure the current in the lightning stroke.

Continued field investigations using portable surge generators and cathode ray oscillographs, were made in conjunction with study of applications of lightning arresters to distribution transformer installations and associated line construction.

Considerable experimental work concerning grounds and ground connections resulted in making available information which may be used to improve the effectiveness of lightning arrester applications.

New protective devices have been developed, arranged for installation inside of the distribution transformer. This development marks a new phase in the problem of protection of transformers against the effects of lightning and should result in very much improved operating experience.

A report is in preparation jointly with the N.E.L.A. Subject Committee on Lightning Arresters, outlining the prevailing practise on the installation, operation, and experience of various types of lightning arresters by a number of the larger operating companies. This information should be valuable in observing the present trend of operating practise on transmission and distribution systems relative to arrester installation, operation, and performance as affecting suitable standards, and also whether tests and equipment should be developed to determine the operating condition of arresters in service.

Lightning arrester manufacturers have contributed largely to the development of more powerful testing equipment and more accurate recording apparatus which has been used to carry out the proposed tests outlined in the Report on Standards for Lightning Arresters and has effectively demonstrated the value of these tests to determine the characteristics of lightning arresters.

The report on Standards for Lightning Arresters continues in its tentative form and it will probably not be feasible to revise this report until work now in progress on the characteristics and coordination of system insulation with respect to lightning has progressed further.

### INTERCONNECTIONS

#### *Report of Joint Subcommittee*

The Joint Subcommittee on Interconnections includes representatives of the Protective Devices, Power Generation, Transmission and Distribution, and the Electric Machinery Committees.

At the Winter Convention 1932 the session under the auspices of the subcommittee included two subjects of particular interest to the Protective Devices Committee, namely, the "Report of the Subject Committee on Definitions of Terms Used in Power System Studies" and the papers presenting revised decrement curves.

The activity of various engineering groups in studies of interconnection has built up a terminology for which there has been no official recognition. A Subject Committee has been at work on these definitions for some time and presented a report that will be used as the basis for the consideration of such definitions by the responsible standardizing bodies. A large number of these definitions is related to subjects of interest to the Protective Devices Committee.

The papers on decrement curves and short circuit calculations are:

*I—Standard Decrement Curves*, W. C. Hahn, General Electric Co. and C. F. Wagner, Westinghouse Electric & Manufacturing Co.

*II—Calculation of Short Circuits on Power Systems*, C. F. Wagner, Westinghouse Electric & Manufacturing Co., and S. H. Wright, Buffalo, Niagara & Eastern Power Corporation.

*III—Decrement Curves for Specific Systems*, W. C. Hahn, General Electric Co.

During 1918, Messrs. Burnham, Hewlitt, and Mahoney discussed decrement curves for relay and circuit breaker applications before the Institute. The group of papers presented at the last Winter Convention brings the subject up to date, utilizing the further knowledge of machine characteristics accumulated in the intervening period.

# Instruments and Measurements

## ANNUAL REPORT OF COMMITTEE ON INSTRUMENTS AND MEASUREMENTS*

THE Committee on Instruments and Measurements during the year 1931–32 has had an active membership of 23 members. At the meeting held in October 15 members were in attendance, and at the meeting held in January 13 members attended. Considering the geographical distribution of the membership, this attendance is exceptionally good.

The work has been organized through subcommittees to take care of the following subjects:

1. Recording instruments
2. Telemetering
3. Definitions of instruments and testing
4. Instrument transformers
5. Indicating instruments
6. Temperature measurements
7. High-frequency measurements

### SUBCOMMITTEE ON RECORDING INSTRUMENTS

This subcommittee has been engaged for several years on the development of standards for recording instruments. During the year its work was completed and a draft of the proposed standards was approved by the Instruments and Measurements Committee. These have been forwarded to the Secretary of the Standards Committee for adoption and publication. This subcommittee has been under the chairmanship of Mr. Kinnard and is to be complimented on the completion of a task which involved such a large amount of painstaking work.

### SUBCOMMITTEE ON TELEMETERING

This subcommittee has concluded its work on standard definitions which have been approved by the Instruments and Measurements Committee. These have been submitted to the Secretary of the Standards Committee.

In addition to its work of following developments in this field, it has undertaken to cooperate with a subcommittee of the Automatic Stations Committee in the preparation of a report on telemetering and supervisory control systems and related communication systems. This report is a very comprehensive survey of all the known telemetering systems, which have been critically analyzed so as to provide detailed information in regard to the limitations and operating characteristics of each. It is hoped to have this report for the Summer Convention. Mr. E. D. Doyle is chairman of this subcommittee.

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* **COMMITTEE ON INSTRUMENTS AND MEASUREMENTS:**

E. J. Rutan, Chairman,
H. S. Baker,
R. D. Bean,
O. J. Bliss,
P. A. Borden,
H. B. Brooks,
A. L. Cook,
E. D. Doyle,
W. W. Eberhard,
Marion Eppley,
J. B. Gibbs,
W. N. Goodwin, Jr.,
I. F. Kinnard,
O. A. Knopp,
A. E. Knowlton,
H. C. Koenig,
W. B. Kouwenhoven,
F. A. Laws,
E. S. Lee,
J. B. Lunsford,
Paul MacGahan,
R. T. Pierce,
W. J. Shackelton,
H. L. Thomson,
H. M. Turner.

### SUBCOMMITTEE ON DEFINITIONS OF INSTRUMENTS AND TESTING

This subcommittee is an outgrowth of the cooperation of the Instruments and Measurements Committee with the Sectional Committee of the American Standards Association which is preparing definitions on instruments and testing. Mr. E. S. Lee as chairman of this subcommittee has been assisted by the chairmen of the Recording Instruments, Telemetering, Instrument Transformers, and Indicating Instruments subcommittees as well as all of the members of the Instruments and Measurements Committee. Many valuable suggestions and considerable work has been done in the criticism, correction, and re-arrangement of several of the drafts of definitions submitted to this subcommittee. Joint meetings were arranged with the members of the Sectional Committee and, as a result, an acceptable draft of these definitions has been completed.

### SUBCOMMITTEE ON INSTRUMENT TRANSFORMERS

The Subcommittee on Instrument Transformers has been active for the past two years in the revision of standards No. 14 and has about completed its work and is preparing to submit a final draft of these standards to the members of the Instruments and Measurements Committee. Mr. J. B. Gibbs is chairman of this subcommittee.

### SUBCOMMITTEE ON INDICATING INSTRUMENTS

Indicating instruments standards No. 23 which have been available to the industry since 1927 have been under consideration for revision during the past year. Based on considerable progress in the art since the standards were issued and the experience of the Instruments and Measurements Committee, many desirable changes will be made and new data incorporated in these standards. An early report from this subcommittee is expected which, upon approval by the Instruments and Measurements Committee, will be forwarded to the Standards Committee. Mr. H. C. Koenig is chairman of this subcommittee.

### SUBCOMMITTEE ON TEMPERATURE MEASUREMENTS

This subcommittee, which is under the chairmanship of Mr. H. C. Koenig, has been working on the preparation of a standard code for temperature measurements. The scope of this work is to cover all the requirements of temperature measurements as specified in the various standards of the Institute. It is expected, when completed, a very comprehensive procedure will be available for uniform measurements of temperature.

### SUBCOMMITTEE ON HIGH-FREQUENCY MEASUREMENTS

This subcommittee has been active under the chairmanship of Prof. H. M. Turner. Arrangements were made to cooperate with a committee appointed by the Standards Committee to draft definitions and standards for sound measurements. The subcommittee is also making a study of vacuum tube voltmeters and will prepare a report on this subject during the coming year.

### INSTITUTE SESSIONS AND PAPERS

In addition to the Committee work through its subcommittees on definite subjects, arrangements were made for the promotion of a session at the Mid-Winter Convention. Six papers were presented and are listed below:

1. *High Voltage Bridge for Measurements of Cable with Grounded Sheaths*, C. L. Dawes and A. F. Daniel.
2. *A High Sensitivity Power Factor Bridge*, W. B. Kouwenhoven and Alfredo Banos, Jr.
3. *Capacitance and Power Factor Measurement by the Capacitance Bridge*, R. P. Siskind.
4. *An Automatic Oscillograph*, C. M. Hathaway and R. C. Buell.
5. *The Photoelectric Recorder*, C. W. La Pierre.
6. *Aging and Elastic Hysteresis in Instrument Springs*, P. MacGahan and R. W. Carson.

In addition to the papers presented at the session, the following papers were reviewed by the various members of the Instruments and Measurements Committee and commented upon:

1. *The Metering of Symmetrical Components*, G. R. Shuck.
2. *Electrical Measurements of Sound Absorption*, A. L. Albert and W. R. Bullis.
3. *Electrical Solutions of Problems of Regular Scheduled Flight*, C. F. Green.
4. *The Photoelectric Recorder*, C. W. La Pierre.
5. *A Standard of Low Power Factor*, W. B. Kouwenhoven.
6. *Electrical Measurements in the Gas Industry*, E. X. Schmidt.
7. *A Special Application of the Potentiometer Principle*, J. L. Watson and R. C. Gleeson.
8. *A Bridge for Precision Power Factor Measurements on Small Oil Samples*, J. C. Balsbaugh and P. H. Moon.
9. *Skin Effect in Rectangular Conductors*, H. C. Forbes and L. J. Gorman.

### CONCLUSION

The Chairman wishes to acknowledge at the completion of his two years of office the hearty cooperation of all of the members of the Instruments and Measurements Committee. The work of the vice-chairman, secretary, and chairmen of the subcommittees was of especial importance in the successful completion of many of the projects which we had before us. From several years contact with this committee as a member and as chairman, the writer has been very much impressed by the interest displayed, and feels highly confident concerning the continued activity in this field of the electrical engineering art as sponsored by this committee.

# Transportation

## ANNUAL REPORT OF THE COMMITTEE ON TRANSPORTATION*

### Railroad Electrification

THE Reading Company began operation on July 26, 1931, of the first portion of its electrified suburban service running out of Philadelphia. Multiple-unit cars are now operated over 64.6 miles of route embracing 156.9 track miles and the electrification of two more branches is in progress, the completion of which will bring the total electrified mileage to 86.9 route miles or 203 track miles. Single-phase, 25-cycle, alternating current is supplied by the Philadelphia Electric Company through outdoor frequency changer sets located on the railroad's property at Wayne Junction, and is distributed to the trains over a 36,000/12,000 three-wire system with 12,000 volts between the overhead contact wires and the rails, and 24,000 volts between the rails and the feeders carried on the catenary structures. Provision has been made on these structures for supporting transmission lines of higher voltage when future extensions of the electrification make it necessary. Over a part of the right-of-way steel towers are to be used jointly by the power company for high-voltage transmission and by the railroad for supporting its catenary system. All of the power switching is handled from a single supervisory control board at Wayne Junction, at which point also are located the repair shops and storage yards for the car equipment.

The Pennsylvania Railroad Company has made very considerable progress on its project for complete electrification between New York and Washington. The overhead contact system has been installed in the New York Terminal zone between Sunnyside Yards on Long Island and Manhattan Transfer in New Jersey, where d-c. third-rail locomotives have been used hitherto, and a-c. locomotives are now handling some of the trains. Construction is progressing between Manhattan Transfer and Trenton, New Jersey, the completion of which, in association with the work already done, will permit electric operation from New York as far as Wilmington. The erection of catenary structures between Wilmington and Washington has been begun. Several locomotives of the new standard designs have been placed in service. The motors on the two types of passenger locomotives (2-B-2 and 2-C-2) and the road freight locomotive (1-D-1) have interchangeable armatures, stators, and other parts, those on the passenger engines being mounted in twin frames, a pair for each driving axle, while those on the freight locomotive are mounted independently one on each of the four driving axles. The motors all have a continuous rating of 625 hp. per armature. Standardization and interchangeability of parts have been carried out as far as possible throughout the design of these locomotives, both in the mechanical parts and in the electrical equipment. These standard motive power units may be operated in various combinations to provide the tractive effort required for different classes and weights of trains.

The New York Central Railroad has eliminated the use of steam locomotives on its "West Side" line in New York City, full operation by either electric or oil-electric locomotives having been inaugurated in June 1931. Third rails supplying direct current at 650 volts have been installed as far south as 72nd Street, but only to a very small extent in the yards between 72nd and 60th Streets. No external power supply has as yet been provided on the tracks which lead (still largely on the city streets) to the smaller yards and terminals further downtown. The locomotives which handle the switching and transfer work in this territory have oil engine-generator sets and storage batteries to provide their own power, but are also equipped to receive power from the third rail where it is available.

The New York, New Haven & Hartford Railroad has placed in operation the ten new passenger locomotives mentioned in last year's report. They weigh 403,000 lb. and have the axle arrangement 2−C+C−2 with a weight on drivers of 45,600 lb. per axle. Each of the six driving axles is connected by quill and gear to a twin motor with a continuous rating of 550 hp. These locomotives are notable for improved motor design, giving better commutation and increased tractive effort.

Oil-electric locomotives, as well as oil-electric and gasoline-electric rail motor cars, are finding an increasing number of applications. Seven such locomotives recently placed in service by the Bush Terminal Company in Brooklyn, New York, are unique in that their cabs, underframes, and trucks were fabricated entirely from structural shapes and plates, with electric welding and no riveting.

Air conditioning on passenger cars and experiments with rubber-tired rail cars are among recent developments in railroading which contain elements of interest to the electrical engineer.

### Railroad Signaling

A number of additional installations of the recently developed methods of centralized traffic control was made during the past year. These, together with the completion of many new interlocking plants, automatic signals, highway crossing signals, and car retarders kept the record of progress in the installation of signaling facilities up to about 65 per cent of that in the previous year in spite of the reduction in the volume of construction in general.

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* COMMITTEE ON TRANSPORTATION:

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J. V. B. Duer,
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I. W. Fisk,
K. T. Healy,
H. N. Latey,
John Murphy,
Hippolyte Parodi,
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R. H. Rice,
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N. W. Storer,
W. M. Vandersluis,
R. P. Winton,
Sidney Withington,
G. I. Wright.

## URBAN TRANSPORTATION

The New York City Board of Transportation has practically completed the equipment of the new Eighth Avenue Subway from Fulton Street to 207th Street, Manhattan, and has received 300 cars which have been tested in trial runs and are ready for the beginning of operation. Five hundred more cars have been ordered in preparation for extension of the service to other sections of the new system which are under construction in the boroughs of Brooklyn, Queens, and the Bronx. The substation equipment for these lines will include 16 converters in five substations with an aggregate capacity of 53,000 kw., and 62 mercury arc rectifiers rated at 3,000 kilowatts each, most of which will be placed in individual subterranean compartments along the subway lines.

Systematic efforts are being continued to design a type of street car which will more successfully meet the competition of the buses and the private automobiles. The tendencies are toward the use of light-weight, double-truck cars, with small wheels and low floors, equipped with small high-speed motors giving rapid acceleration and high car speeds. Control has been improved by the use of a larger number of resistance steps and also by the introduction of "variable-automatic control" in which the operation of the resistance contactors is governed by relays, but the motorman can select the rate of acceleration according to traffic or rail conditions. Braking by means of electromagnetized shoes on the car acting against the running rails is being used to some extent. Higher speed and lighter weight are the tendencies in interurban cars also, and some attention is being given to improvement in body design to reduce wind resistance.

The use of trolley buses is being extended, such vehicles having been purchased for seven cities during 1931, at the end of which year there were 225 trolley buses in operation in 14 cities in the United States.

## MARINE TRANSPORTATION

The two largest passenger liners built in the United States, the *President Hoover* and the *President Coolidge*, were placed in operation during the past year in intercoastal and transpacific services. Each of these twin ships has two 10,000-kw. turbine-driven generators which supply the synchronous-induction propulsion motors with three-phase, alternating current at 4800 volts, and also four 500-kw. turbine-driven d-c. generators which very completely serve the auxiliary equipment on board, including steering gear, winches, capstans, air compressors, refrigerating machines, blowers, pumps of all sorts, elevators, cooking equipment, stateroom heaters, fans, etc., in addition, of course, to searchlights and general lighting. Several other smaller motor-propelled vessels with generators driven by steam turbines or oil or gasoline engines were placed in commission during the year. (See also the report of the Committee on Applications to Marine Work.)

## AERIAL TRANSPORTATION

The U.S. Navy dirigible *Akron* carries considerable electrical equipment, including a searchlight and general lighting, cooking appliances, radio equipment, a battery charging set and other motors. The energy is supplied by two 11-kw., 115-volt d-c. generators driven by gasoline engines. The huge mooring mast, by which the dirigible is towed into and out of its hangar at Lakehurst, N. J., is propelled by two caterpillar tractors driven by 125-hp., 250-volt, d-c. motors and is steered by a third caterpillar driven by an 8-hp. motor. A 240-hp. gasoline-driven generator supplies these motors as well as floodlights and signaling apparatus on the mast and equipment for conveying water, fuel, and electricity to the dirigible.

A novel type of electric locomotive is used to tow models of sea-plane hulls or pontoons in a testing channel 2,000 ft. long, 22 ft. wide, and 12 ft. deep, recently completed at Langley Field, Va. The towing car spans the tank and is driven by four 75-hp. motors. The remarkable feature is its rapid acceleration, as it is said to reach a speed of 60 miles an hour in 9 seconds.

Important improvements were made during the year in radio equipment for communication between airplanes and the ground and for direction finding. These include automatic volume control, which relieves the pilot of the necessity of making manual adjustment of receiver amplification over a wide range of distances, and also practicable means of giving visual indication in connection with the direction finders.

Among electrical devices perfected for application to aviation may be mentioned an instrument for indicating engine cylinder temperature which is so calibrated and compensated as to show directly in degrees the temperature of various parts of the engine where thermocouples are installed. The leads from several thermocouples are brought to the indicator through a selector switch. Another device is the sonic altimeter in which a compressed air whistle produces signals electrically timed and controlled, which are reflected from the ground. The echo is heard in a stethoscope and, by means of a timing indicator mounted on the instrument panel, the time interval between outgoing and returning signals is interpreted directly in terms of distance above the ground.

## VERTICAL TRANSPORTATION

The opening of the Empire State Building in New York City in 1931 placed in service the largest installation of elevators yet made. These are all of the automatic type and those serving the upper part of the tower have higher speeds and longer vertical travel than any previously installed. Improvements in construction and in the control of emergency stopping devices now permit speeds up to 1200 ft. per minute.

An installation of double-deck elevators, serving two floors simultaneously, has been made in the tower of the new Cities Service Building in New York City. In this same structure there is also the first installation of escalators in an office building, a means of transportation which is being used more and more extensively in department stores, railway stations, etc.

The arrangement, mentioned in last year's report, in which two independent elevators are operated in the same shaft, one running express to the upper floors and the other serving the lower floors, with suitable safety interlocking, appears to be a thoroughly practical development. Such elevators are in service in one of the Westinghouse buildings in East Pittsburgh.

# Applications to Marine Work

## ANNUAL REPORT OF COMMITTEE ON APPLICATIONS TO MARINE WORK*

As in the past few years, the major items of activity of the committee have been:

1. Accumulating, as a result of experience, data for revision of Standards No. 45, Recommended Practise for Electrical Installations on Shipboard.
2. Promoting the idea of establishing a definite status of the electrical operating personnel on shipboard.
3. Following closely installations of electric propulsion and electrification of auxiliaries on shipboard.

### STANDARDS NO. 45

These standards are proving to be more and more useful to naval architects, shipbuilders, ship operators, and manufacturers of electrically driven auxiliaries. As a result of this increase in use, it is natural that changes and additions should be found desirable. During the past year the committee has continued to collect data for such revisions and when the volume of this data seems to justify a reissue of the standards, the committee expects to recommend such action to the Institute.

### OPERATING PERSONNEL

For some years the committee has felt it important that the personnel in charge of the electrical machinery on ships should have a more definite status than is now in vogue. With the increasing use of electricity for both propulsion and auxiliaries, the necessity for such a recognized status has become more urgent. Our first efforts were based upon improving the status of electrical operating personnel through governmental channels, but as a result of experience, it has become apparent that our efforts will probably meet with more success if we cooperate with the owners and operators of vessels to this end; hence, during the past year we have been in further conferences with the American Steamship Owners Association and we believe that we are about to arrive at such a working agreement with this association as will lead to definite results.

### ELECTRIC PROPULSION AND AUXILIARIES

As stated in last year's report, the year 1930 was one of great activity, progress and accomplishment in marine engineering, generally. This was due largely to the passage of the Jones-White Merchant Marine Act in 1928. This activity resulted in contracts being let for a large number of ships with electric propulsion and auxiliaries.

Due to the present financial depression the past year has not been marked by such activity, but the program started the year before has continued to be executed without cancelation of contracts.

The following table shows the status during the year of new ships in the U.S.A. equipped with electric propulsion:

SHIPS COMMISSIONED IN THE U.S.A. DURING 1931

*Turbine Electric Drive*

| Name | Type | Horsepower |
|---|---|---|
| *PRESIDENT HOOVER* | Passenger Cargo | 26,500 |
| *PRESIDENT COOLIDGE* | Passenger Cargo | 26,500 |
| *TALAMANCA* | Passenger Cargo | 10,500 |
| *CAYUGA* | Coast Guard Cutter | 3,220 |
| *SHOSHONE* | Coast Guard Cutter | 3,220 |
| | Total | 69,940 |

*Diesel Electric Drive*

| Name | Type | Horsepower |
|---|---|---|
| *COLUMBINE* | Lighthouse Tender | 240 |
| *LINDEN* | Lighthouse Tender | 240 |
| *GULF MIST* | Tanker | 400 |
| *WHITE FLASH* | Tanker | 375 |
| *SAN DIEGO* | Ferry | 750 |
| *DUPLEX* | Dredge | 600 |
| | Total | 2,605 |

SHIPS UNDER CONSTRUCTION IN THE U.S.A. DURING 1931

*Turbine Electric Drive*

| Name | Type | Horsepower |
|---|---|---|
| *SEGOVIA** | Passenger Cargo | 10,500 |
| *CHIRIQUI* | Passenger Cargo | 10,500 |
| *ANTIGUA* | Passenger Cargo | 10,500 |
| *QUIRIGUA* | Passenger Cargo | 10,500 |
| *VERAGUA* | Passenger Cargo | 10,500 |
| | Total | 52,500 |

* Destroyed by fire Dec. 1931.

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* COMMITTEE ON APPLICATIONS TO MARINE WORK:

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W. Hetherington, Jr.,
H. L. Hibbard,
J. E. Kearns,
Alexander Kennedy, Jr.,
J. B. Lunsford,
I. H. Osborne,
G. A. Pierce,
W. H. Reed,
H. M. Southgate,
W. E. Thau,
John Van der Dussen,
A. E. Waller,
O. A. Wilde,
J. L. Wilson,
R. L. Witham,
W. N. Zippler.

*Diesel Electric Drive*

| Name | Type | Horsepower |
|---|---|---|
| ——— | 3 Tugs | 1,600 |
| ——— | 1 Yacht | 600 |
| | Total | 2,200 |

*Gasoline Electric Drive*

| Name | Type | Horsepower |
|---|---|---|
| *JOHN T. HARVEY* | Fireboat | 2,130 |

# Production and Application of Light

## ANNUAL REPORT OF THE COMMITTEE ON PRODUCTION AND APPLICATION OF LIGHT*

## PRODUCTION OF LIGHT

### *Statistics on Lighting Progress as Indicated by Incandescent Lamp Sales*

THE production and use of artificial light, as indicated by the sale of incandescent lamps, decreased slightly during 1931 as compared with previous years. In actual numbers of lamps sold the decrease was not great. The average wattage decreased from 61.2 to 60.9 watts, lamp efficiency from 13.3 to 13.4 lumens per watt and average lumens from 814 to 817.

The continued increase in the use of 120 volts for lighting circuits is notable. The percentage of 120-volt lamps sold increased from 41.3 per cent in 1930 to 43.9 per cent in 1931, while 110- and 115-volt lamps decreased from 5.2 per cent to 3.7 per cent and 48.9 per cent to 48.0 per cent, respectively. The adoption of the three-phase four-wire network system of distribution is probably the major factor influencing this trend.

Street lighting continues to show an increase both in the number of lamps used and in the average light output.

## NEW INCANDESCENT LAMPS

### *Photoflood Lamps*

A companion lamp for the photoflash lamp has been developed—the photoflood lamp. The photoflash lamp is intended for use in making snapshots, while the photoflood lamp is intended for time-exposures and for home or amateur motion picture photography. The new lamp has a bulb of the same size and shape as the standard 60-watt lamp but is rated at 250 watts and operates at an extremely high efficiency. In light output it is equivalent to a standard 500-watt lamp but in photographic effect, due to a high percentage of actinic light, it compares with a 750-watt lamp.

### *Neon-Filled Christmas Tree Lamps*

Christmas trees are illuminated usually by strings of eight 15-volt lamps burning in series. The failure of one extinguishes the entire string and it is necessary to try each successive lamp in the string until the burned-out lamp is located. Neon-filled lamps have been developed which operate in the usual manner until one fails. This impresses the full line voltage across that particular lamp and causes it to glow with the characteristic neon red. As the current producing the glow is not sufficient to light the remaining lamps, the burned-out lamp is identified readily.

### *Inside Frosting 150 to 500-Watt Lamps*

The inside frosted finish has been made available for lamps of 150 to 500 watts. This finish is desirable for lamps used in light density enclosing globes and in indirect lighting units since it diffuses the light and eliminates sharp shadows.

### *Addition of 1,500-Watt Lamps*

Increasing use of high intensity illumination produced a demand for 1,500-watt lamps sufficient to warrant their inclusion in the regular lamp schedules.

### *Elimination of 600- and 800-Lumen Lamps*

Authorities on street lighting practise consider the use of lamps of less than 1,000 lumens output inadvisable. The 600- and 800-lumen, 6.6-ampere lamps have been removed, therefore, from the regular schedules.

## IMPORTED INCANDESCENT LAMPS

Electric lighting in America has enjoyed a favorable lamp situation in that a great majority of the lamps supplied to the public have been of well-controlled quality and of highest practicable efficiency. This condition is threatened now with impairment due to the advent of inferior lamps. Notable among these are lamps imported from Japan and sold through irregular channels of distribution. The Committee is informed that aside from miniature lamps, about twenty millions of Japanese lamps were imported during the last year. These were characteristically of such low efficiency that at prevailing rates for current the public could not afford to use them.* Defects which interfere with satisfactory service were unduly prevalent among them and their life performance was very irregular and inconsistent.

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H. H. Higbie,
C. L. Kinsloe,
R. D. Mailey,
G. S. Merrill,
P. S. Millar,
P. H. Moon,
R. E. Simpson,
C. J. Stahl,
G. H. Stickney.

In drawing attention to this development, the Committee bespeaks coöperation of electrical engineers generally in doing all that may be practicable to prevent the impairment of American lighting by lamps of inferior quality.

### BASE AND SOCKET STANDARDIZATION

At the present time the screw bases and sockets standard in Europe differ slightly from the original American Edison standard in such a way that American lamps are not assured of fitting in European sockets, but European lamps can be put in American sockets, though failing to meet American safety requirements. Although many more American sockets and bases are in actual use, it was proposed to adopt the European design as the international standard. At a meeting of the International Electrotechnical Commission's Committee, held concurrently with the 1931 sessions of the International Commission on Illumination, the American standards were recommended on a par with the European and plans were advanced looking toward a single universal standard of intermediate dimensions.

### PROPER OPERATING VOLTAGE

The voltage at which incandescent lamps are operated affects their input, output, efficiency, rate of depreciation, and cost of producing light to such an extent that it cannot be overlooked in any consideration of the production and application of light involving such sources.

The N.E.L.A. Lamp Committee Report for 1930–31* contains a study of operating voltages in use in some 24,590 communities. The detailed figures presented in the report reveal an undesirable tendency toward the increased use of more than one standard voltage in individual communities. Such dual standards make it difficult, if not impossible, to insure that lamps of proper voltage are used. During the five-year period from 1923 to 1928 there was a marked reduction (13.2 per cent to 5.4 per cent) in the extent to which two lighting service voltages were used by any one community, but in the last years this has increased again.

### WIRING SPECIFICATION

Of the specifications mentioned in last year's report, the "Minimum Specification for Wiring of Lighting Circuits in Industrial Structures" was issued during the summer.

Regarding residence wiring, several associations undertook independently the development of specifications. An industry committee was organized to coördinate the work and prepare amplified specifications acceptable to all groups. This work is reported now to be complete, subject to final approval by the several associations. It is understood that the proposed specification sets No. 12 wire as the smallest size to be recommended for any lighting circuit. This limitation, corresponding as it does to that of the commercial and industrial specifications, should help eliminate smaller sized wire from good standing with the designers of electric light wiring, and thus advance good engineering in this field.

### CARBON ARCS

Recent careful control tests of various sources of illumination with respect to their speed and color reproduction in photography have shown that the white flame photographic carbon almost exactly duplicates the results obtained with natural sunlight

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* *Transactions*, Illuminating Engineering Society, November 1931.

* N.E.L.A. Bulletin—Sept. 1931, p. 627.

**Table I—Data on Incandescent Type of Ultra-Violet Sources**

| Source | Type S-1 | Type S-2 | Type G-1 Lamp | CX Lamps | | |
|---|---|---|---|---|---|---|
| | | | | 60-watt | 300-watt | 500-watt |
| Approximate lamp watts | 400 | 130 | 36 | 60 | 3000 | 500 |
| Approximate total watts with auxiliaries | 500 | 175 | 50 | 60 | 300 | 500 |
| Approximate transformer primary amperes | 9 | 3 | 1 | | | |
| Approximate operating volts | 14–15 | 15 | 18–20 | 110–115–120* | 110–115–120* | 110–115–120* |
| Approximate operating amperes | 27.5 | 8.5 | 2 | 0.5 | 2.6 | 4.3 |
| Approximate lumens | 8400 | 1850 | 150 | 785 | 6000 | 10,750 |
| Approximate lumens per watt (lamp) | 21 | 14.2 | 3.7 | 13.1 | 20 | 21.5 |
| Approximate over-all lumens per watt | 16.8 | 10.5 | 3.0 | 13.1 | 20 | 21.5 |
| Bulb | PS-22 inside frosted | A-17 clear | A-21 inside frosted | A-21 inside frosted | PS-30 inside frosted | G-38 inside frosted |
| Base | Mogul screw | Special screw | Medium screw | Medium screw | Mogul screw | Mogul screw |
| Maximum over-all length—inches | 6 7/16 | 4 7/8 | 4 1/4 | 4 15/16 | 7 1/8 | 7 5/8 |
| Light center length—inches | 5 | 3 3/4 | 2 3/4** | 3 3/8 | 5 | 5 |
| Foot-candle minutes for MPE | 3500 | 6500 | 1300† | 175,000† | 120,000 | 100,000 |
| Approximate life—hours | 400 | 400 | 500 | 500 | 500 | 500 |
| List price | $7.50 | $3.75 | $3.50 | $1.00 | $3.00 | $3.50 |

N. B. Burning the Types S-1 and S-2 lamps at an angle of 45 degrees reduces their ultra-violet outputs 30 and 40%, respectively. Eliminating the wire screen on the Type S-1 units increases their output about 20%.

* Also available for 28–32 volt circuits.

** Since the entire bulb glows this dimension is base contact point to center of bulb which is also the center of the electrodes.

† Estimated.

and gives a nearly perfect separation of color values in effective shades of gray.

In the field of motion picture projection, carbons have been developed which are steadier in burning and, in certain sizes, even higher in intrinsic brilliancy than those formerly obtained.

Precratering of high intensity positives has resulted in a more rapid burning in of natural craters and full intensity of illumination, as well as a resultant saving in costs by reducing the possibility of mirror or condenser pitting.

For searchlights used in airport floodlighting and military purposes, carbons have been developed which will give from 50 to 100 per cent more light at 225 and 250 amperes than has been possible previously with regular searchlight carbons.

## ULTRA-VIOLET—INCANDESCENT TYPE

Last year's report mentioned the introduction of four new sources of ultra-violet radiation emitting little or no wavelength shorter than 2,800 and, therefore, safe for use in the home, the school, office, et cetera; *i. e.*, the Types S-1 and S-2 lamps, the Type G-1 or glow lamp and the CX lamps.

Considerable improvement has been made in these sources since their introduction. The essential technical data pertaining to them are given in Table I.

During the year very complete lines of fixtures have been placed on the market for the Types S-1 and S-2 lamps. Suspension and ceiling type units have been developed which have a spread of both the ultra-violet radiation and the visible light flux. Such units are finding wide application in places where the exposure periods are somewhat limited, such as in swimming pools, gymnasiums, hospital solariums, lunch and recreation rooms, et cetera.

For use in offices, schools, et cetera, where it is desired to combine the health maintenance value of ultra-violet radiation with the lighting over exposure periods of 6 to 10 hours, a third line of equipment, known as dual-purpose lighting fixtures, has been developed. Most of these utilize regular incandescent lamps for indrect or semi-indirect lighting and also an ultra-violet lamp and reflector so designed as to spread a mild intensity of ultra-violet over a wide area.

## GASEOUS TUBE ELECTRIC ILLUMINANTS

It has long been felt that possibilities of materially higher efficiency of light production lie in the domain of electrical discharge through gases rather than in incandescence. While incandescent lamps, with which most artificial lighting is accomplished, are serving the purpose exceedingly well, despite limitations of theoretical low efficiency of light production, and are undergoing gradual evolution which appears to bring them closer and closer to the limits of the possibilities of production of light by incandescence, the engineering world is favorably predisposed toward the idea of achieving efficiencies of a higher order from gaseous tube illuminants.

The present low-voltage gaseous and mercury-vapor arc tubes make available to the illuminating engineer additional lighting tools having characteristics that possess value for particular purposes. Thus the mercury arc lamp, with its characteristic green-blue light, provides a "work light" which has peculiar value for certain industrial applications. The arc tubes of neon or other gases, with their characteristic instantaneous response to electrical discharge, are especially useful in television, stroboscopic work, et cetera. Further, the vivid colors of these tube illuminants make them applicable for certain special uses, such as aircraft beacons, and for publicity purposes. These sources, however, are of the same order of efficiency as tungsten filament lamps.

Beyond these developments the committee has information only of experimental developments in low voltage gaseous arc tube sources. Among these the highest efficiencies of light production attained are in tubes of high power. Pirani's oft-cited sodium tube of special sodium-resistant glass, heated independently to 350 deg. cent. and enclosed within an outer evacuated tube, is said to attain 70 lumens per watt applied to the tube itself. It produces light of a brilliant yellow color. No data are available as to the power required for the complete equipment. Neon and mercury-vapor low-voltage arc tubes, three or more feet in length and consuming 1,000 to 2,000 watts, are said to attain to 35 to 50 lumens per watt. In smaller sizes of lower power input very much lower efficiencies of light production are attained.

In the opinion of the committee attempts to develop gaseous arc tube light sources of a materially higher efficiency than modern incandescent lamps are interesting and perhaps promising. Of practical achievement in the way of commercially applicable illuminants the committee has nothing new to report at this time.

## APPLICATION OF LIGHT

### *New and Improved Incandescent Lamp Equipment*

The standard dome reflector and the glassteel diffuser remain as standard lighting equipment for industrial areas. Recent developments have improved the methods of hanging these reflectors so as to reduce the time required and the cost of cleaning and relamping. The high intensities of light required on certain working areas can be secured by the use of recently developed industrial projectors which can be mounted on the ceiling, side walls or columns and adjusted to project the light in any desired direction.

A totally enclosed semi-indirect lighting unit has been developed with the bottom of the bowl of high density glass and the top portion practically clear. This type of glass makes a highly efficient unit and one easily maintained.

Appearance of the lighting equipment is playing a very important part in commercial installations. The contours of enclosing globe units are more pleasing in design and hangers are receiving considerable attention from the design standpoint. An interesting development in the indirect type of unit is one constructed entirely of metal louvers which can be obtained in a variety of color finishes.

Outdoor lighting such as the floodlighting of buildings and areas devoted to outdoor sports is increasing in popularity. This is partly due to the development of more efficient floodlight projectors and the introduction of open type floodlights. Many manufacturers have discarded the plain parabolic mirror for compound curves forming 2 and 3 surface mirrors. This increases the efficiency and permits accurate control of the beam.

The floodlighting of homes for holiday decorations, and gardens during the summertime, is now made possible by the development of small floodlight projectors designed for use with 100- and 150- watt lamps.

### *Street Lighting*

Street lighting has been referred to frequently, by engineers, as the application of electric light where the practise has lagged most behind growing needs. During the year the demand for smaller municipal expenditures has been reflected in numerous proposals for reduced street lighting. Considerable apprehension was felt by experts lest serious increases in traffic and crime hazards should be incurred for only negligible savings. So far no extensive reduction has been made and several cities, where reduced lighting was tried, returned promptly to former illumination. On the other hand there has been a definite arrest in the advance of street lighting.

### *Group Replacement of Lamps*

Since incandescent lamps operate with almost no attention and a substantial proportion of them last beyond their economic efficiency, many installations fall below their proper illumination performance. The obvious cure is systematic cleaning and replacement at suitable intervals. A recent awakening to the importance of such practises is showing good results. Already about thirty utility companies are applying "group replacement" to their street lighting. Noticeable improvement in illumination and reduced outages are being secured at little, if any, increased expense. Similar methods are applicable to traffic signals, large buildings, large signs, and wherever lamps are grouped in sufficient numbers to permit economic organization of maintenance.

In connection with group replacement, it is desirable to segregate used lamps which have considerable life expectancy from those which are approaching failure. This is facilitated for clear bulb lamps by a new inspection box, which reveals filament defects.

### *Railway Signals in Locomotive Cabs*

Many serious accidents on railroads have resulted from failure of the engine crew to see signals. A new system, being applied extensively by a leading railroad, has a light signal in a conspicuous position in the locomotive cab, where it is independent of weather conditions and its view not limited to a fleeting glance. A sound device calls special attention to changes. The enhancement of safety is obvious.

### *Sports Lighting*

The increasing popularity of artificial illumination in this field is due to the use of more adequate levels of lighting. For example, in football fields about 15 foot-candles have been found to be desirable in contrast to the 5 to 7 foot-candles often recommended in the past. For baseball fields a consumption of about 300 kw. is considered necessary now, whereas 200 kw. was about the maximum of former attempts.

### *Lighting of Buildings Exteriors*

The application of artificial light to the exterior of buildings is making rapid progress, especially in the endeavor to create artistic night-time effects. Lighting effects formerly obtaining only by floodlighting are, in some of the newer buildings, being improved upon by novel methods. Today architects are designing buildings with the idea of artistically lighting the exteriors at night. They are paying attention to the direction of light projection and so designing as to create night-time as well as day-time effects on their buildings. One development is the use of luminous panels built into the façade of the building. Pilasters of diffusing glass behind which are mounted various colored lamps connected to dimmers produce changing color effects. Entire façades are covered with panels of this sort or constructed of glass brick which can be illuminated from behind at night. The development is following gradually that of built-in lighting for interior use.

### *Built-In Lighting*

It is illogical to wait until a building is completed before considering lighting equipment, yet in the past this was generally the case. Now, fortunately, in most new structures the artificial lighting is designed as a component part of the interior. Manufacturers of diffusing material, such as glass, molded plaques and translucent substances, have made available many new varieties and these are finding application. Conventional fixtures designed on traditional lines are passing rapidly from the picture.

### *Residential Lighting*

While the number of newly electrified homes in 1931 decreased to one-seventh the number added in 1930 and to one-seventeenth the number added in 1929, the consumption of electrical energy in homes showed an increase of approximately 8 per cent in 1931, only three or four points less than the increase in previous years when new residential building was at high levels. Decreasing hours spent in the various places of entertainment outside of the home have meant increasing evening hours at home for all members of the family, calling for a greater use of electric light.

The portable lamp has grown in popularity as is evidenced by the increasing number of styles and designs which have been produced. The indirect portable lamp using a 200- or 300-watt lamp has not usurped this field although it has continued to grow in numbers. Decorative floor and table lamps using the Type S-2 lamp have made their initial appearance.

Lighting fixtures providing indirect or semi-indirect lighting and selling at very low prices have been received favorably in various parts of the country for the relighting of certain rooms of the homes of "minimum bill" customers. The design of these fixtures is such that they may be fastened directly to existing single sockets.

The President's Conference on Home Building and Home Ownership devoted a section of its Fundamental Equipment Report to the Wiring and Lighting of the Home, giving attention to these home modernizers equal to that devoted to such items as heating, ventilating, and plumbing.

### *Automobile Lighting*

By means of a three-filament headlamp, a lighting system has been developed giving an asymmetrical distribution of light with reference to the car axis in which more light is directed to the right side of the road, particularly when passing another car. This system is so arranged that a city-driving and a country-driving range of light control is provided.

The advantages of directing more light to the right when passing are well recognized and several auxiliary lighting units are available which when used in connection with the present standard dual beam system provide this desirable passing light.

On some cars the fender lights serve a dual purpose, the switch control being so arranged that in addition to acting as marker lights when the car is parked these fender lamps are lighted when the beam is depressed, thus showing the oncoming driver that the depressed beam is being used and giving in addition an indication of the extreme width of the car.

Two rear lamps are being supplied for many current model motor cars. These lamps are generally a combination rear and signal unit. The majority of rear units are equipped with reflex glass which gives an indication from the reflected light thrown on it. The use of reflex materials in conjunction with incandescent lamps is considered desirable from a safety standpoint. Incandescent lamps are being used also to indicate when the engine needs oil and whether or not the battery is being charged.

Present day headlamp equipment, which is mostly of the fixed focus type, is capable of furnishing good road illumination with a minimum of glare but in order to obtain the maximum advantage from this equipment additional educational work is still needed which should be directed along the lines of encouraging car drivers to use the lower or depressed beam when meeting or signaled by oncoming cars.

### *Daylight vs. Artificial Light*

Recently developed lighting equipment provides artificial light with supplementary ultra-violet radiation, exceeding that received from daylight filtered through window glass. This, coupled with improved electrical air conditioning, is rendering building construction independent of natural illumination. In a number of buildings recently completed or under construction, daylight has been purposely excluded.

### *Architectural Relations*

Each year architects show a growing interest in the decorative as well as utilitarian possibilities of modern lighting. The Illuminating Engineering Society, in cooperation with the Beaux-Arts Institute of Design, has established an Illuminating Engineering Society Prize for which architectural students throughout the country compete. This year's project is designing the lighting for an exhibition hall at a world's fair. It is planned to continue this prize competition for the next decade.

The American Institute of Architects is cooperating with the Illuminating Engineering Society in the revision of the American Standard Code of School Lighting.

### *Light Control*

The photoelectric light control relay is a device which regulates automatically the turning on and off of artificial lighting as the intensity of daylight decreases or increases. During the year such control was applied to the lighting of a school room where children in a special "sight-saving" class receive their instruction. Tests conducted in this room indicated that in order to maintain an intensity of 15 foot-candles, it is necessary to use the artificial lights at least 30 per cent of the time the room is in use.

Thyratron control of lighting is being applied to theaters, floodlighting of buildings, show windows, and electric fountains.

Thermionic tubes appear especially applicable for automatic dimming controls, where the only moving part can be small potentiometers or phase shifters actuated by very small motors. Applications of mobile color lighting with these controls include a floodlighted building, dance halls, night clubs, restaurants, and a number of theaters.

One of the most recent developments utilizes a continuous belt for controlling the potentiometer adjustment by providing a conducting path for each color or group of lights to be controlled. Any desired combination can be secured by varying the position of the conducting paths on the belt, so that any predetermined lighting effect can be repeated at will, or a new combination can be secured by "changing the roll." It is reported that the first installation of this arrangement will be to control the lighting of Buckingham Fountain in Chicago.

With the new thermionic tube controls the manual switchboard for theater and stage lighting can be very small, located in the orchestra pit, on the stage, or even in the front rows of the orchestra. Now the "lighting conductor" becomes a reality and the lighting of the show is played by the conductor who sees and hears the entire action.

### *Illuminometer*

A new portable illuminometer employing the photoelectric principle has become available. The photonic cell consists of a disk on which has been deposited light-sensitive material so that, when exposed to light, a slight but apparently constant electrical potential is generated. The readings are made on a microammeter connected to the cell by means of a flexible conductor cord.

For increased deflections two or more cells are sometimes mounted in a single housing and connected in multiple. Measurements and checks under incandescent lighting of the range ordinarily found indoors seem to show comparatively close agreement with the usual types of visual illuminometers.

### *Lighting Plans for 1933 Chicago Fair*

A wide interest and curiosity has been exhibited by the public regarding the illumination of the 1933 Fair. It is not appreciated generally that the interiors of the Fair buildings will have no natural light. They will be illuminated both day and night by electricity. In general there are no windows or other openings through which natural light may enter.

One novelty will be shimmering effects on exterior walls such as is produced by reflection of the sun's rays from bodies of water in the daytime. A lighting projector built upon this principle will be used to throw fantastic moving color patterns on building walls. By agitation of the water in different ways, patterns of various forms may be produced. So-called scintillators will be used also. In this case squares of polished metal trembling on delicate supports will flash dancing color patterns over large areas of frosted glass. This is one of the few lighting effects that can be utilized in the daytime. The rays of the sun are allowed to penetrate the glass at many points and are reflected back by the metal squares in lively fashion, somewhat similar to the heliograph used by the Army for signal purposes.

Fluorescence will be used also. Many objects such as flowers, foliage, statuary, et cetera, will be treated with fluorescent materials and under so-called invisible light will appear in contrast with the surrounding foliage.

The possibility of fluorescent fountains has not been overlooked. There are several organic substances that may be added to water to produce fluorescence, such as eosine, fluorescene, and aesculin. Very small quantities of these substances added to water in a circulating fountain are sufficient to impart a mysterious glow to the water under so-called invisible light.

During the last few months the Fair has been experimenting with a great so-called flaming ladder arc, using a potential of 33,000 volts. Rising from a huge outdoor transformer will be two electrodes about thirty feet high. A flaming arc will start from the bottom of these electrodes and travel upward. As this intense flame dissipates at the top, another automatically starts at the bottom, so that there is a succession of fiery bridges or rungs in constant motion. Hence the term "ladder arc." As these arcs travel upward, dry chemical salts are injected by compressed air. These salts impart changing colors to the arc stream.

### *International Commission on Illumination*

The International Commission on Illumination met in Cambridge, England, the week of September 13, 1931. In connection with the meeting a Congress was held in which meetings assembled in London, Glasgow, Edinburgh, Sheffield, Buxton, and Birmingham. Many notable demonstrations of illumination were made for these events and the subsequent celebration of the Faraday Centenary, among which were the lighting of the public buildings and streets of London and Edinburgh Castle. Excellent progress was made toward international understanding on illumination problems.

A new topic was Aviation Lighting in which international unity is especially important.

## GENERAL

### *Revised Nomenclature and Standards*

During 1931 there has been widely circulated for discussion and criticism a revised set of terms and definitions to supersede the American Standard "Illuminating Engineering Nomenclature and Photometric Standards" issued in 1925. The changes which have resulted from this discussion are largely matters of form rather than of substance. The new edition of the nomenclature will show, therefore, few radical departures from the established practise, but is believed to be somewhat more clear and logical.

### *Primary Standards of Light*

International discussion of fundamental photometric problems has continued and several laboratories abroad are reported to have in progress experimental tests of the form of primary standard proposed by the Bureau of Standards. This standard consists of a refractory tube immersed in molten platinum at its freezing temperature. The tube is so constructed and observed as to be a "complete radiator" or "black body." Its brightness as found at the Bureau of Standards is 58.85 candles per square centimeter. The question of accepting this standard is before the International Commission on Illumination and the International Committee of Weights and Measures, but a decision must await independent confirmation of the Bureau's results by some other national laboratories.

### Death of Thomas A. Edison

The Committee on Production and Application of Light cannot conclude its report without allusion to the passing of the founder of the electric lighting industry. His death on October 18, 1931, was the signal for an expression of worldwide appreciation of the services and of the life of the man whom electrical engineers have held in high regard by reason of his inauguration of electric light and power as a widespread service to the public. Edison passes but his work goes on. He lives in the esteem of those who carry on under the banner which he raised.

# Applications to Mining Work

## ANNUAL REPORT OF THE COMMITTEE ON APPLICATIONS TO MINE WORK*

THE past year has been one of very greatly reduced activity in all classes of mines. New machines and new applications of electricity in mining work have been few and, generally, of a minor nature. There has, of course, been no incentive to force production or to increase the capacity of mines, and labor-saving devices have not been in demand because of an unwillingness on the part of operators to aggravate the bad unemployment situation. However, there have been some installations and devices worthy of comment.

A West Virginia coal mine has installed a passenger elevator to expedite the movement of men in and out of the mine and to relieve the production hoist of this service so that it can continue in its regular duty. This elevator has all of the safety and control features of a high-speed traction-drive office elevator. It handles twenty men per trip in a shaft 347 feet deep at a speed of 450 feet per minute. As this elevator travels in the intake air compartment, the car has certain special structural features to permit an uninterrupted flow of air.

Some companies have found it profitable to operate their mines only at night to secure a lower rate for electric power at the off-peak period. Power economies have also been effected by the use of power demand limiters. An installation of capacitors for power factor correction has shown a return of approximately 7 per cent per month.

Two new electric cap lamps for use in gaseous mines have been developed. One of these, weighing only 63 ounces, gives a beam candlepower of 26 at the beginning of a shift and the other, which weighs only 87 ounces, gives a beam candlepower of 55 at the beginning of the shift. A flood lamp, particularly designed for lighting the face for cutting and loading, gives a beam candlepower of approximately 350. All of these lamps have been approved by the U. S. Bureau of Mines.

Improved performance is being regularly obtained from cutting and loading machines. One operator reports that a cutting machine regularly cuts 1,000 to 1,200 tons in 6 to 7 foot coal in a shift, and that he is regularly obtaining 375 tons per day from his loading machine.

A Western Pennsylvania mine has installed a system of automatic door control, using "the electric eye" as the controlling relay. The mine doors are caused to open and close in proper sequence for either direction of movement of the trip.

A wound-rotor induction motor with direct-current excitation of the primary has been installed as a braking generator to replace mechanical brakes, holding a rope haul trip at proper speed down grade. The high expense of brake maintenance has been practically eliminated.

Several large induction motors and synchronous motors with automatic line-start control have been installed for pumping in the anthracite field. The controls for several of these are housed in cubicles and completely erected at the factory.

A large, high-speed, heavy-duty, variable-voltage hoist, taking its power from a synchronous motor-generator set, has been installed in Canada. The rotating equipment consists of a 1,250-kw. generator, an 1,800-hp., 750-r.p.m. synchronous motor and a 1,550-hp., 68-r.p.m. hoist motor. The skip has a capacity of 6 tons of rock per trip and travels at a speed of 2,200 feet per minute.

A new light-weight self-propelled cutting machine has shown favorable results over several months of trial. The machine has a very high-speed cutter which resembles in its operation a band saw more than the usual type of cutter.

The construction of new coal-cleaning equipment kept pace with progress of previous years in this line. It is estimated that 8,000 tons per hour of complete mechanical cleaning capacity were installed in 1931 in addition to 20,000 tons of capacity for cleaning and sizing. All of these tipples and cleaning plants were, of course, electrically driven.

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*COMMITTEE ON APPLICATIONS TO MINING WORK:

D. E. Renshaw, Chairman,
A. R. Anderson,
Graham Bright,
J. H. Edwards,
E. J. Gealy,
L. C. Ilsley,
L. H. James,
J. E. Kearns,
Carl Lee,
W. H. Lesser,
C. W. Parkhurst,
F. L. Stone,
J. F. Wiggert,
C. D. Woodward.

# Transmission and Distribution

## ANNUAL REPORT OF COMMITTEE ON POWER TRANSMISSION AND DISTRIBUTION*

THE activities of the Committee on Power Transmission and Distribution have continued through the past year along the lines organized in previous years. Various subjects of interest to the Institute membership have been treated in a number of papers presented before the conventions and district meetings.

A brief outline of the activities of the several subcommittees follows:

### SUBCOMMITTEE ON STEEL TRANSMISSION TOWERS AND CONDUCTORS

Subjects relating to steel towers have been studied and certain items of general interest are now being given particular attention preliminary to the preparation of future reports.

A report has been drafted outlining the requirements for modern steel tower transmission lines which, after review, it is expected will be published. Conductor vibration has been given intensive study. A direct result of this work has been the publishing of a bibliography including all available data on the subject of vibration. A session at the Summer Convention is devoted to this important subject.

### SUBCOMMITTEE ON DISTRIBUTION

Continued consideration has been given to the various broader aspects of distribution, including developments in secondary and primary networks.

Of particular interest to distribution engineers is the symposium presented at the Winter Convention consisting of six papers on distribution circuit lightning protection. This symposium summarized the results of intensive field and laboratory experimental work and analyses of operating experience. It is believed that this material will be productive of improvement in distribution equipment and construction practises and in service reliability.

### SUBCOMMITTEE ON CABLE DEVELOPMENTS

There have been no marked innovations in the cable art during the past year, although study has been continued on the developments indicated in previous reports. In the high voltage transmission cable field, the highest voltage submarine cable crossing in the world, across the Columbia River near Portland, Oregon, is also the first of the oil-filled type used in submarine work. The cables are 750,000-cir. mil., single-conductor, rated at 115 kv., and an insulation thickness of 0.550 inch. An unusual feature is the use of hard-drawn-copper armor wires, instead of the usual steel, in order to reduce the losses in the armor and thereby increase the rating to 114,000 kva.; over 30 per cent more than if steel armor had been utilized.

The performance of experimental installations of 132-kv. cables, one of the oil-filled type with reduced insulation and the other of the solid type, in Chicago and in Newark, respectively, has continued to be successful.

### SUBCOMMITTEE ON INTERCONNECTION AND STABILITY

The joint subcommittee on interconnection is formed from representatives of the Power Generation, Protective Devices and Power Transmission and Distribution committees. During the year the scope of the committee was increased and representatives were added from the Committee on Electrical Machinery.

This joint subcommittee sponsored a session at the Winter Convention on the subject of Decrement Curves and Power System Stability. Two other stability papers were presented during the year.

### SUBCOMMITTEE ON LIGHTNING AND INSULATORS

The necessity for establishing a definite wave or group of waves by which to measure impulse strength of insulators has been recognized for some time. In the interest of greater uniformity in test practises, agreement has been reached on a tentative group of waves (1) which would closely approximate the effects of natural lightning voltages imposed on apparatus connected to transmission systems; (2) which could be produced with available laboratory equipment; and (3) on which considerable impulse data have already been secured by various laboratories which have been investigating the performance of insulation under impulse voltages. The following three waves have been agreed upon as preferred test waves for impulse testing. These waves are designated as $^{1}/_{2}$ x 5, 1 x 10, and $1^{1}/_{2}$ x 40. The first number indicates the microsecond time to crest, and the second number the time in microseconds from zero to 50 per cent of crest on the tail.

Another development in the lightning field has been continued this year in the factory test of commercial transformers with artificial impulse waves. It appears that the manufacturers are now in a position to test commercial transformers in the higher voltage ranges with artificial impulse waves, and a recommendation has been made that a committee formulate the procedure to be followed in applying impulse waves to transformers. This work is already in progress.

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* **COMMITTEE ON POWER TRANSMISSION AND DISTRIBUTION:**

**P. H. Chase, Chairman,**
**L. N. Conwell, Vice-Chairman,**
**T. A. Worcester, Secretary,**
**Sydney Alling,**
**F. E. Andrews,**
**A. B. Campbell,**
**C. V. Christie,**
**A. E. Davison,**
**H. C. Dean,**
**L. L. Elden,**
**R. D. Evans,**
**F. M. Farmer,**
**T. H. Haines,**
**Edwin Hansson,**
**K. A. Hawley,**
**L. F. Hickernell,**
**D. C. Jackson, Jr.,**
**J. P. Jollyman,**
**A. H. Lawton,**
**I. E. Moultrop,**
**L. L. Perry,**
**T. F. Peterson,**
**D. W. Roper,**
**A. E. Silver,**
**D. M. Simmons,**
**C. T. Sinclair,**
**L. G. Smith,**
**H. H. Spencer,**
**Philip Sporn,**
**W. K. Vanderpoel,**
**C. F. Wagner,**
**H. S. Warren.**

Field investigation of natural lightning which has been in progress for the last few years has been continued on a decreased scale.

Discrepancies in 60-cycle flashover values of insulators mentioned in last year's report as due to humidity conditions have been further studied this year. Papers fully covering this subject have been presented before the Institute during the year.

Reference has been made above to the field, laboratory, and operating investigations relating particularly to 2,300- and 4,000-volt distribution lightning protection. Of particular interest is the apparent benefit to be derived from interconnecting the primary arrester ground with the secondary neutral, if the latter is well grounded.

### CONCLUSIONS

In conclusion, the committee wishes to express its gratification at the interest evidenced in the field of Power Transmission and Distribution by the papers submitted and by the attendance and discussion when presented.

This interest together with that displayed by the members of the committee, and by those associated in the work of its subcommittees, have made possible the accomplishments of the committee.

# Power Generation

## ANNUAL REPORT OF THE COMMITTEE ON POWER GENERATION*

ALTHOUGH the past year has recorded no major strides in power plant design and construction not heretofore discussed in committee reports, the committee has been successful in obtaining a variety of papers of a critical nature for Institute presentation, surveying present practise, with the object of indicating probable lines of advance when the construction of new or additional power projects again becomes active. Following the custom of preparing progress reports only at biennial intervals, the committee report for the past year will merely recount briefly the results accomplished by the several subcommittees engaged in planning and securing technical papers.

The Joint Interconnection Subcommittee, of which F. C. Hanker served as chairman, was instrumental in presenting at the Winter Convention six papers embracing several phases of the subject of stability of power systems, including that of *Stability of Conowingo Hydroelectric System*, by R. A. Hentz and J. W. Jones. A record of the most recent technical advances in power system design and operation was given in that paper. Another valuable paper concerned the standardization of nomenclature regarding stability, being a report by H. K. Sels.

Another session at the Winter Convention was sponsored by the subcommittee on Power Station Auxiliaries, composed of H. W. Leitch and F. H. Hollister. The comparative merits of steam and electric drives for steam power stations were analyzed in papers by W. Poole Dryer and L. W. Smith, advocating opposing views, and in a summary statement by F. H. Hollister.

A subcommittee headed by N. E. Funk has arranged a symposium of four papers on *Combined Economy and Reliability in Operation of Large Electric Systems*, for the Summer Convention. Current practise in the Boston, Chicago, Detroit, and Philadelphia areas will be discussed at that time.

Other work consisted of a review by I. E. Moultrop and J. B. Crane of the economics of the design and use of high-temperature and high-pressure steam equipment, with a supplementary discussion of the use of welding in modern fabrication methods. A paper on this subject awaits opportunity for presentation. The subcommittee on Hydroelectric Practise, J. P. Hogan, chairman, will offer a paper by A. V. Karpov on *Low-Head Hydroelectric Developments* at a Fall District Meeting featuring other papers on hydroelectric subjects. F. A. Annett of the subcommittee on the Design of New Plants has reviewed papers describing the Waukegan and Ashtabula plants, and has cooperated in having the subject of power generation adequately represented on the program of the Pacific Coast Convention this summer.

The Committee recommends that the recent innovations in the design and application of switching structures at power plants be given major attention during the coming year. For that purpose a subcommittee, A. E. Silver, chairman, was appointed which has been assembling data and information for a discussion of that topic next winter.

The Committee wishes to take this opportunity to record its thanks for the assistance given by the several authors and the many discussers of papers to the end that the progress in the field of Power Generation be adequately reported by the committee.

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* **COMMITTEE ON POWER GENERATION:**

J. R. Baker, Chairman,
F. A. Allner,
F. A. Annett,
D. S. Brown,
Andrew Carnegie,
J. B. Crane,
E. A. Crellin,
R. D. DeWolf,
W. P. Dryer,
N. E. Funk,
W. S. Gorsuch,
F. C. Hanker,
L. F. Harza,
J. P. Hogan,
F. H. Hollister,
A. H. Hull,
H. W. Leitch,
A. H. Lovell,
E. B. Meyer,
I. E. Moultrop,
F. A. Scheffler,
F. O. Schnure,
R. E. B. Sharpe,
A. E. Silver,
A. R. Smith,
E. C. Stone.

# General Power Applications

## ANNUAL REPORT OF COMMITTEE ON GENERAL POWER APPLICATIONS*

DURING the past year the committee has not sponsored a session at any of the meetings or conventions, but has reviewed and reported upon a number of industrial papers. Two of these papers were presented at the Pacific Coast convention at Lake Tahoe, August 1931, and as far as we know these were the only industrial papers presented at district meetings before the Institute during the year. These two papers are as follows:

*Electrical Equipment for Oil Field Operations*, by H. C. Hill and J. B. SeLegue

*Electric Power in the Wood Products Industry*, by C. E. Carey and K. L. Howe

Although the general activity of practically all industrial plants and machinery manufacturers has been greatly curtailed during the year, nevertheless, this extremely competitive situation is responsible to some extent for a number of developments and improvements in industrial equipment which have been brought out. Last year we mentioned the interest that was being shown in connection with the use of electronic tubes for industrial applications. The various characteristics which these tubes possess which are not otherwise obtainable are almost daily finding new industrial uses. A large number of these applications falls under the classification of process control and are in line with the trend of the time toward elimination of waste, reduction of cost, an more accurate control of all manufacturing processes Most of these electronic developments are give publicity in the various trade papers or in *Electronics* and to keep posted on such activities constant contact with such literature is necessary. A comprehensive review in a report of this kind is entirely impossible.

During the year considerable attention has been given by various electrical machinery manufacturers to the design and construction of motors, controllers safety switches, push-buttons, and other details to meet the requirements for Class II Hazardous Locations as defined by the Underwriters' Laboratory. Such equipment, although required for such locations in flour mills, grain elevators, starch plants, coal pulverizing plants, etc., finds numerous other desirable applications where its installation results in lower maintenance cost and improved operating conditions.

Instead of attempting to abstract information regarding the numerous developments in industrial apparatus or application, the committee feels that members interested in such equipment can readily obtain such information directly and more completely from the various periodicals as, for instance, *The Electrical World*, *Maintenance Engineering*, *G. E. Review* or *Electric Journal*, together with the various specific industry magazines. The January issue of such magazines generally contains a review of the year's achievements in a much more complete and interesting form than could be given in a report of this kind.

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* COMMITTEE ON GENERAL POWER APPLICATIONS:

C. W. Drake, Chairman,
A. H. Albrecht,
E. A. Armstrong,
James Clark, Jr.,
J. F. Gaskill,
John Grotzinger,
Truman Hibbard,
Fraser Jeffrey,
A. M. MacCutcheon,
H. A. Maxfield,
John Morse,
N. L. Mortensen,
A. M. Perry,
D. M. Petty,
H. W. Rogers,
L. D. Rowell,
W. K. Vanderpoel,
M. R. Woodward.

# Iron and Steel Production

## ANNUAL REPORT OF COMMITTEE ON APPLICATIONS TO IRON AND STEEL PRODUCTION*

### GENERAL

IT is estimated that the steel industry expended approximately 35 million dollars in 1931 for the purchase and installation of new apparatus, the maintenance of old equipment, and in the purchase or generation of electric power.

During the year there were purchased 63 main-drive motors of more than 300 rated hp. each. The total rated horsepower of these drives aggregated 119,325 hp. These figures compare with the installation of 163,490 hp. which occurred in the year 1930.

A major trend toward increased use of refined control equipment for automatically performing tasks which had previously required manual labor was continued during this year. While such equipment was installed at a reduced rate in 1931, the percentage of men whose duties were no longer required in the steel industry due to such automatic devices increased.

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* COMMITTEE ON APPLICATIONS TO IRON AND STEEL PRODUCTION:

A. C. Cummins, Chairman,
F. B. Crosby,
Wray Dudley,
J. B. Fries,
S. L. Henderson,
A. M. MacCutcheon,
F. O. Schnure,
W. B. Shirk,
G. E. Stoltz,
T. S. Towle,
H. A. Winne.

### MAIN AND AUXILIARY DRIVES

The 44-inch universal slabbing mill in the Chicago District, referred to in last year's report as being under construction, was completed during the early part of 1931. The upper and lower main horizontal rolls are driven by two 5,000-hp., 40/80-r.p.m., 700-volt, double-armature reversing motors; and the auxiliary vertical rolls are driven by a 2,500-hp., 79/225-r.p.m., 700-volt, single-armature reversing motor. The total continuous capacity of the three motors is 12,500 hp., and the maximum emergency capacity about 35,000 hp., nearly a third greater than any similar mill. The three motors are connected in parallel and are supplied with variable-voltage direct-current power from a 10,500-kw., 5-unit, six-bearing flywheel motor-generator set, consisting of three 3,500-kw., 700-volt generators, a 6,500-hp., three-phase, 25-cycle, 6,600-volt, 370-r.p.m. wound-rotor induction motor and a 180,000-lb. flywheel. When running at synchronous speed, the total stored energy in the rotating parts of the motor-generator set is approximately 270,000 hp-seconds. Latest operating data indicate this installation has proved quite successful.

A recent installation of induction motors and control for operating "catcher tables" has fulfilled the expectations of not only the operators, but of the mill designers and electrical manufacturers as well. These tables are used in the rolling of sheet steel and take the place of the older manual methods of handling the sheets and packs during the rolling process. The cycle of operations includes carrying the material into the mill by means of the roller table, receiving it on the catcher table, tilting the tables upward, transferring the sheet over the top roll back to the roller table, returning the tables to the down position, and reversing the direction of travel back into the mill. This cycle of operation must be completed under some circumstances in three seconds, which means that the motors must be capable of reversing or starting at the rate of 40 times per minute.

Special low-inertia, low-speed motors have been developed to cover this type of application. The speeds used are 375 r.p.m. for 25-cycle supply and 450-r. p. m. for 60-cycle supply. The use of squirrel-cage motors for such duties as this has been attempted only within the past two years, but it is an indication of the changing trend toward the application of simplified motor and control apparatus. Formerly, direct-current mill-type motors were thought the only solution for such problems.

During 1931, the first American installation for producing seamless steel tubes by the "push bench method" was completed. In the production of seamless steel tubing by this method, a heated blank is placed in a hydraulic press and formed into the shape of a thick walled thimble. The thimble is then placed on the end of a mandrel and forced through a series of stationary ring dies, which gradually decreases the wall thickness, and at the same time elongates the thimble, thus forming a long tube with a closed end. After the elongated thimble has been forced by the mandrel through the various dies, the mandrel is withdrawn and the closed end of the tube sawed off. Sizing and finishing is carried on subsequently in mills of the usual design. The power required on this application is approximately the same as that used by the piercing process.

In the installation just completed, the mandrel is forced forward through the dies by means of a rack and pinion which is driven by a 1,500-hp. variable-speed d-c. reversing motor. The control for this equipment is so arranged that upon indications from the operator, the motor will start, accelerate the ram, force the material through the dies at a predetermined rate of speed, then stop, reverse, and return the mandrel to the initial position. Means are provided for adjusting the speed of the stroke over a wide range, and extremely fast acceleration and retardation are necessary to meet the operating cycle. Devices are arranged in connection with this control to prevent the ram from overrunning in either direction. The manufacture of tubes by this process is expected to produce a small seamless tube at very low cost and for this reason it is probable that additional installations of similar equipment will follow.

Two steam engine drives in the Pittsburgh District were replaced by motor drives. A three-high roughing mill driven by a 1,500-hp. steam engine has been re-equipped with a 1,600-hp. wound-rotor induction motor. Likewise a reversing steam engine on a two-high finishing mill has been replaced by a 1,250-hp., d-c. reversing motor. This reversing equipment is said to be one of the smallest applications in the steel industry of reversing main roll drive equipment.

There have been two major hot strip mill installations made during the year. One of these consists of a 72-inch continuous hot strip mill and the other a 76-inch continuous hot strip mill. It is understood that both of these mills are equipped with anti-friction bearings on the main rolls throughout, and combine the use of induction motors on the preliminary stands, synchronous motors on the intermediate stands and d-c. adjustable-speed motors on the finishing stands. It is unusual to find the three types of main roll drive combined in one mill installation, but it was possible on these particular mills to secure the necessary relations between peripheral roll speeds without the use of expensive adjustable-speed d-c. drives throughout the entire mill.

The largest motor equipment ever sold for driving a cold strip mill was also installed during the year. Each of the two stands of this cold strip mill are driven by a 1,500-hp. adjustable-speed, d-c. motor. A tension reel driven by a 400-hp., adjustable-speed, d-c. motor, receives the material from the two cold roll stands. It is apparent that the year has witnessed a change in the electrical equipment used in the rolling of both hot and cold strip.

New designs of electric contactors were announced by one of the leading manufacturers during the year. Decided progress was made by a committee of steel mill engineers toward the standardization of control equipment. It is felt that it will be but a short time until a satisfactory steel mill control standard will be an accomplished fact.

Several new tension-limiting devices were designed.

for automatic reeling applications. Some are designed to place a predetermined tension on reels coiling strips after they are rolled, while others are between stands of the finishing passes. Automatic screw-down equipment for two-high and universal mills of simplified design appeared. This apparatus uses electron tubes to replace cumbersome limit switches. However, no installations of this type of screw-down control have been completed at the time this is written. Automatic screw-down control assures uniformity in rolling practise, independent of the whim of the operators, and has resulted in a material improvement in the quality of the product of rolling mills where it has been in service. The apparatus used in the past has been quite complicated and it is felt that the new devices tending to simplify this type of equipment will prove to be a worth while development and result in more general use.

## SYNCHRONOUS MOTOR CONTROL

The recent remarkable increase in the use of synchronous motors in steel mills has made their characteristics, operation, and control a subject of great interest to steel mill electrical engineers. The favorable status of the modern synchronous motor was not achieved, however, until definite limitations of the earlier designs were overcome. Modern design and construction have removed most of these earlier limitations until now the synchronous motor starting, pull-in, and pull-out torques are exceptionally favorable for applications heretofore reserved for induction and direct-current motors.

A recent development of unusual interest has taken place in control systems for synchronous motors. This development is the culmination of investigations started many years ago which have done much to extend the field of application of the synchronous type motor. Recent systems of control automatically start the motors under the best conditions, in the shortest time, and keep them running through nearly all power supply disturbances of a transient nature. In short, modern synchronous motor control eliminates many of the starting and operating difficulties, which prevented their extensive acceptance in industrial fields.

Modern synchronous motor-control systems comprise the following separate features:

1. Part winding starting, resulting in reduced starting kva.
2. Transfer to full voltage by means responsive to the electrical condition of the field winding.
3. Synchronizing by means responsive to the electrical condition of the field winding.
4. Delayed low-voltage release.
5. Field kick-off and resynchronizing (where the load permits).
6. Unloading and reapplication of load to driven machine.

Not all of these features are required for every application, but those are employed that accomplish best possible starting under all conditions and continuous operation through momentary power or load disturbances.

## ELECTRIC FURNACES

Several installations of electric furnaces for bright annealing coiled steel strip were completed and placed in operation during the year. Each furnace consists of a bell type heating chamber and several bases or cars upon which the coiled strip is stacked. An inner hood or cover of heat-resisting alloy is placed over the stack and serves to exclude air both during the heating period and while the coils are being cooled. An atmosphere of illuminating gas or other suitable gas is maintained under the hoods to prevent oxidation.

A new type of furnace, applicable especially to annealing steel sheets, has been developed in which a load of material can be cooled in the furnace in a comparatively short time. With previous types, the cooling rate of a loaded furnace is so slow as to make furnace cooling impracticable. The new furnace is lined with light weight refractory brick so that the heat storage in the furnace walls is comparatively small. It employs a circulating system for the furnace atmosphere, with an external cooler by means of which the heat may be extracted and the furnace again charged at a more expeditious rate than was possible heretofore.

## MATERIAL HANDLING

There has been installed in the Pittsburgh District a large ore bridge using a bucket of 17 tons capacity. The bridge span is approximately 190 ft. The outstanding feature of the bridge is the unusual use of compressed air for control. Ten motors, 275 to $7^1/_2$ hp., are controlled by electropneumatic type control, similar in design to standard railway equipment. This arrangement, it was found, required less space and lower maintenance. The brakes are spring set and air released for quick, positive stopping. Due to the large volume of air required, there are three sets of compressors and reservoirs, one in the operating cab and one in each leg of the bridge. The bridge in normal service can handle 1,000 tons an hour and serves several blast furnaces located nearby.

## ELECTRONIC DEVICES IN THE STEEL INDUSTRY

The past year has seen a rapid increase in the number, diversity, and ingenuity of applications of electronic devices in the iron and steel industry. These devices are now controlling shears, soaking pit covers, repeaters, and various mill table operations.

In one plant, a flying shear is located between the intermediate and finishing stands of a 10-inch hot strip mill. This shear is to cut off the relatively cool front end of the bar before it enters the finishing stands. Formerly an operator was necessary to trip the shear when the strip was in the proper position, so as to cut off a definite crop length. Now a photoelectric tube automatically trips the shear. An adjustable time-delay relay is used to determine the time interval between the interruption of the beam of light and the starting of the shear, thus compensating for the changes in the strip speed.

In another plant, considerable trouble was encountered in maintaining a flag switch on a back blooming mill table, used to control the operation of a recording pyrometer. A photoelectric tube with the required amplifier unit and relays now performs the operation in a more reliable and accurate manner.

Several installations have been made which permit crane operators to control heating furnace doors by means of photoelectric equipment. A number of other steel mill applications of photoelectric devices have been made, such as skip-hoist limit stops, stock-bin level indicators, spotting of material in reheating furnaces, pyrometers, etc.

. . . .

All in all, 1931 has, in spite of adverse conditions, brought into being a number of new ideas and electrical developments in the iron and steel industry. Cooperative exchange of information has continued, and permitted the industry to benefit from individual as well as collective effort and development.

The Chairman wishes to express his appreciation for the assistance rendered by the members of the committee in the preparation of this report.

### Bibliography

The committee submits a list of the principal papers that have been presented or published by various engineering societies covering more completely many of the subjects reviewed in this report.

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# Communication

## ANNUAL REPORT OF COMMITTEE ON COMMUNICATION*

### COMMITTEE AFFAIRS

THE Committee on Communication continued the practise of outlining at the beginning of the Institute year tentative communication programs for each of the subsequent scheduled Institute meetings. In making up the year's outline, the Committee strove to select material which would be of broad interest to the Institute as a whole and, in particular, to foster the presentation of papers on subjects that had not been covered before or that had received but little recent attention. A successful endeavor was made to cover such subjects in a rather complete and thorough way. The advance planning of programs greatly aided this by allowing the Committee ample time to solicit authoritative papers discussing all the major aspects of each subject selected for extended treatment.

The more important groups of coordinated papers which in accordance with this general policy have been presented at Institute meetings during the past year are:

*Symposium on Communication Services for Power Companies*—1931 Summer Convention:

This was prepared with the cooperation of the Committee on Transmission and Distribution and is headed by a general review of the subject prepared by a joint subcommittee of the Committee on Communication and the Committee on Transmission and Distribution, followed by a group of individual papers prepared by power and communication engineers, discussing the solution of this problem in specific cases.

*Symposium on Time and Time Services*—1932 Winter Convention:

This is headed by two papers discussing the astronomical aspects of time and its measurement, followed by discussions of the time services given by the Naval Observatory, the telegraph companies, and the power companies. In arranging this symposium the Committee on Communication had the cooperation of the Committee on Transmission and Distribution.

*Symposium on Traffic Control*—Northeastern District Meeting, May 1932:

This is headed by a general discussion of traffic control followed by papers describing various electrical systems now having important fields of application.

*Planning for Telephone Toll Service*—Southwestern District Meeting, October 1931:

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H. M. Turner,
F. A. Wolff.

A group of three papers discussing, respectively, the forecasting of population, the general advance planning of telephone toll facilities, and certain technical problems involved in their design.

In addition, a number of individual papers has been presented under the auspices of the Committee at various national and regional meetings during the year, discussing important phases of new developments in the telephone, telegraph, and radio arts. The total number of communication papers, including the symposiums, presented at these meetings during the year was 33.

The communication sessions have been very well attended. The Communication Committee proposes to continue during the coming year its plan of developing programs involving groups of coordinated papers covering subjects of broad general interest.

## ADVANCE OF THE ART

In line with the aim to keep this report as short as practicable there are listed below only a few of the outstanding advances made in the field of communication last year.

During the year the Bell System introduced teletypewriter exchange service whereby any subscriber to this new service may secure a direct connection to any other subscriber over which the two may carry on instantaneously reproduced two-way typewritten communication with one another. The methods and switching equipment employed in establishing connections are similar to those employed in telephone practise.

Also during the year the Western Union Telegraph Company and the Postal Telegraph-Cable Company jointly inaugurated a new form of telegraph service known as "Timed Wire Service." This is available to customers who have simplex printers, and provides for the transmission of communications from any printer to any other at rates based on the time the facilities are in use, rather than on the number of words transmitted. Printer customers desiring this service will obtain connection at the central office with an automatic reperforator, which will directly prepare a perforated tape in form for retransmission to the city of destination without additional manual handling. At this point a second perforated tape will be automatically prepared and used for retransmitting the message to the customer addressed. The service is somewhat analogous to a one-way private wire connection, although a direct connection is not established. The Timed Wire Service routine permits of a more economical utilization of the trunk wire plant than would be possible were a direct connection of printers established.

An automatic concentrator was developed for use on printing telegraph circuits to provide faster and more economical service on customers' lines. The Postal Telegraph Company has installed several of these equipments.

A four-wire voice-frequency carrier telegraph system adapted to meet the requirements of a strictly telegraph plant was developed and an initial installation was made on the lines of the Postal Telegraph Company.

A new cable and radio operating center, serving jointly the Commercial Cable Company, the Mackay Cable and Telegraph Company, and All America Cables, was placed in operation last year. Circuits linking the United States with Europe, Central and South America, and the Far East terminate in this center and connect 85,000 miles of under-sea telegraph wires through 19 separate channels. Three cables to Central and South America and two New York-London cables have been equipped with recently developed printer apparatus which has greatly increased the accuracy of reception and has also effected substantial economies. A recently developed method for converting the non-uniform length signals of the Cable Morse Code into a modified 5-unit code, so as to permit of the operation of printers on long non-loaded submarine cables, is employed in connection with these printers.

A pneumatic tube carrier routing device has been developed by the Western Union Telegraph Company for automatically selecting and diverting tube carriers from a main tube into the proper branch tubes. Pneumatic tubes are used to carry telegrams between main and branch offices and between points in large main offices.

Recent achievements in cable making have included the standardization of cables of less than 1,800 pairs employing 26-gage wires, and the application of a new process of insulating small-gage conductors for exchange cables. Under the new method of insulating the cable wires, a coating of wood pulp is applied to each conductor from a bath of water-suspended pulp. This coating when it dries becomes a continuous uniform sleeve of porous paper surrounding the wire. Cables made from this material are of the same size and have practically the same operating characteristics as cables of the older type, for which wires are insulated by helical wrappings of thin, narrow manila paper ribbon. Four machines for producing pulp-insulated wire were placed in operation last year with an output capacity of about 200,000,000 feet of wire a week.

Bermuda, Hawaii, Rio de Janeiro, Java, Sumatra, and the Canary Islands were brought into telephone communication with the interconnected telephone system of North America by means of radio links established in the past year. The first three places are reached by direct radio circuits from the United States. Communication between the sending and receiving stations at Oahu, and the other islands of the Hawaiian archipelago, is secured by an ultra-high-frequency radiotelephone system put into service by the Mutual Telephone Company. This system is also used regularly in inter-island telephone service.

Single side-band transmission of short-wave radiotelephony was successfully demonstrated by the International Telephone and Telegraph Laboratories. The spread side-band system for use on short-wave radio telephone links has also been developed by means of which distortion effects due to selective fading can be largely eliminated. By an extension of the principles involved, a number of side bands can be placed on one carrier in such relative positions to each other and the carrier that harmonic distortion as well as crosstalk between channels is eliminated.

A successful demonstration of two-way radiotelephony on an 18-cm. wavelength was given across the English Channel by the International Telephone and Telegraph Laboratories. This system, called "micro-ray," employs an antenna only 2 cm. in length. The greater directivity of these short waves makes it possible to employ the same wavelength for a number of separate channels closely spaced as to geographical separation, without mutual interference. Because of this, and the wide frequency band thus opened up, the commercial application of the "micro-ray" would make available nearly a quarter of a million additional radio channels.

Improvements have been made during the year in controllers for pre-timed traffic signals. One type is arranged so that signals may be automatically operated on different time cycles at different periods of the day or week. Another type is primarily intended to operate in connection with a flexible progressive system, but may be also used to meet the special requirements of detached street intersections. This provides for several functions in addition to the usual automatic stop-and-go control: manual control, flashing amber on one street and flashing red on the cross streets; lengthened green on the main street, pedestrian period, fire lane at one or more of the intersections and varying go periods at different intersections, while preserving the total cycle for progression.

# Cleveland Repeats Its Invitation

## To the Annual Summer Convention, June 20-24, 1932

**The committees are working hard to assure you a profitable and entertaining visit. No registration fee.**

Cleveland Museum of Art, inspection of which is included in the ladies' entertainment program for Monday, June 20, 1932

Canterbury Country Club, where play for the golf tournament will start on Monday, June 20. A new trophy has been provided by Past-President R. D. Mershon to take the place of the time-honored Mershon trophy which was permanently won last year, and a new trophy has been given by Past-President W. S. Lee. A large number of prizes, including four trophies for an A.I.E.E. District team competition, will be provided by the local sports committee.

# Industrial Notes

**Air Conditioning Department for G-E.**—The organization of an air conditioning department within the General Electric Company, which will market various electrical devices for home heating, humidifying, and temperature control, has been effected, and one of the first products to be marketed by this new department will be a complete oil burning furnace. J. J. Donovan, of Cleveland, formerly in charge of apartment house refrigeration sales, will be manager. Associated with him will be E. D. Harrington, of Schenectady, in charge of application engineering; J. R. Rue, of Pittsfield, in charge of manufacturing, and H. S. Woodruff, of Schenectady, in charge of design engineering. Headquarters will be maintained at General Electric's New York offices, 120 Broadway.

**American Steel & Wire Company Opens New Warehouse.**—A new Chicago warehouse located at 2364 South Ashland Avenue is announced by the American Steel & Wire Company. The new depot supplants the Lake Street site and has the distinct advantage of a near south side location.

**New Lifting Magnet.**—The Electric Controller & Mfg. Co., 2700 East 79th St., Cleveland, Ohio, announces a new size, heavy duty lifting magnet known as the No. 3½ type SA magnet. The new magnet is an intermediate size and intended for use with overhead, crawler, or other type cranes in foundries, scrapyards, etc. It requires a 5 kw., direct-current generator.

**A New Dead-End Clamp.**—The Ohio Brass Company, Mansfield, Ohio, has developed a new universal strain clamp to meet the need for a small, inexpensive dead-end clamp. It is designed especially for use in stringing distribution lines, substation buses, low current transmission lines, and overhead ground wires. Although of light weight, this new clamp will develop an ultimate of at least 10,000 pounds. High slip strength is provided by the "V" shaped seat and by the curvature of the clamp body. All conductors for which the clamp is designed are held securely in its grip. By means of a reversible keeper piece, A.C.S.R. or copper conductors from No. 6 to 4/0 may be accommodated. Clamps are supplied with or without a ball and socket eye. The clevis of the clamp may be connected directly to any of the other standard O-B clevis type suspension insulators and hardware.

**Stibloy Now Produced by New Koppers Company.**—The Stibloy Products Company, Inc., with principal offices in the Koppers Building, Pittsburgh, has taken over the assets of Liquid Metal Products, Inc., Chicago, producers and distributors, under the Arent patents, of Stibloy, a metal compound in liquid form, which acts as a primary coating to hold paint, enamel, and lacquer tenaciously, permitting immediate finishing of new galvanized metal surfaces. Stibloy was developed to extend the life of galvanized surfaces by protecting them from the effects of atmospheric conditions and from the damage caused by exposure to gases, acid fumes, smoke, and brine. It is used for protecting galvanized roofing, fences, screens, transmission towers, substations, and other galvanized products. Officers of the Stibloy Products Company, Inc., control of which has been acquired by the Koppers Products Company, are: president, J. N. Forker; vice-president, S. H. Bell; secretary, John D. Shaner; and treasurer, S. T. Brown.

**New Multiple-Duct Concrete Conduits.**—Two new designs of multiple-duct concrete conduits for underground high tension power cables and low tension telephone cables have been perfected by the McCracken Machinery Company, Sioux City, Iowa, which also produces equipment for their automatic manufacture. The concrete units are said to be non-fusible, with extremely smooth interiors, made in four-foot lengths, and the concrete, when adequately cured, develops a crushing strength of over 4,000 pounds per square inch, with less than 8 per cent absorption and waterproof resistance against 15 pounds hydrostatic pressure. For low tension lines the complete unit joint is grouted to prevent water filtration, but the ducts within the unit are not jointed. For high tension cables each duct is jointed independently. The extreme heat of short circuiting will not fuse the concrete, and the danger of a burnout damaging neighboring lines is said to be remote. The units are low in production cost as the manufacturing machine has a capacity of 30 duct-feet per minute of 6-way conduit, 20 duct-feet of 4-way conduit, and 10 duct-feet of 2-way conduit. Installation costs are reduced because narrower trenches will serve, joints are cemented before being placed in position, no extra excavation is needed to allow for plastering joints, and the units are laid at greater speed. The new multiple-duct type conduit has been adopted for important work in Uruguay by the International Telephone and Telegraph Company.

# Trade Literature

**Circuit Breakers.**—Catalog 5, 16 pp. Describes Roller-Smith air circuit breakers, both open and enclosed; attachments and accessories of all kinds; relays and sectional steel, dead-front switchboards and cubicles. A complete line of the latter is offered and such switchboards may be made up of air circuit breakers, oil circuit breakers, indicating and recording instruments, dead-front knife switches or combinations of all four. Roller-Smith Co., 12 Park Pl., New York.

**High Voltage Testing Equipment.**—Bulletin GEA-1168A, 12 pp. Describes standard apparatus for making high potential tests on insulating oil, bushings, and solid dielectric material, and for conducting high voltage investigations. General Electric Co., Schenectady, N. Y.

**Fuse Links.**—Bulletin, 4 pp. Describes the "Bi-Metal" fuse link, a new development in fast blowing, low temperature fuse links for expulsion cutouts. Line Material Co., So. Milwaukee, Wis.

**Floodlighting.**—Bulletin 777, 28 pp. Describes various principles of floodlighting and includes numerous photographs of different types of installations. A simple method of planning floodlighting is outlined. Curtis Lighting, Inc., 1123 W. Jackson Blvd., Chicago, Ill.

**Diverter Pole Generator.**—Bulletin 55, 4 pp. Describes Diverter Pole generators for charging motive power batteries, which meet the standard specifications of the Electric Truck Manufacturers Association. The Electric Products Co., 1725 Clarkstone Rd., Cleveland, Ohio.

**Testing Machines.**—Bulletin 28, 36 pp. Describes hydraulic testing equipment for determining the physical properties of materials. Contains illustrations of typical installations, including the four million pound machine recently shipped to the University of California, claimed to be the largest universal testing machine in the world. Baldwin-Southwark Corporation, Philadelphia, Penna.

**Meter Test Kits.**—Bulletin. Describes types KS and KF meter test kits. Specifications—25 ampere capacity; light load current controlled by four toggle switches in fixed steps totaling 2½ amperes; full load current between 2½ and 25 amperes is controlled by rheostats, which provide a means for readily compensating for any variation in external impedance. A handy current indicator shows the current reading while the load is in use. The States Co., New Park Ave., Hartford, Conn.

**"De-ion" Circuit Breakers.**—Bulletin C1939, 8 pp. Contains a general description of a new line of "De-ion" circuit breakers. These breakers use a new method of arc extinction that enables elimination of all fuses in panel boards, distribution switchboards within the breakers' capacity and industrial applications where fused safety switches are now used. Bulletin C1937 describes construction and application details of the 225-ampere breaker. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Penna.

**Specifications for Butt-Treatment of Poles.**—Bulletin, 4 pp. Contains specifications for the butt-treatment of Western red and Northern white cedar poles, incised process (Pentrex), as adopted by the Western Red Cedar Association and the Northern White Cedar Association. Bulletin, 2 pp., includes the specifications for the "B" process (no specific penetration guaranteed). Bulletin, 2 pp. Describes "AA" process (no specific penetration guaranteed). Naugle Pole & Tie Co., So. Wabash Ave., Chicago, Ill.

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Leaching plant of the Inspiration Consolidated Copper Company at Inspiration, Ariz. This plant has an operating capacity of approximately 80 tons of electrolytic copper per day, with power supplied through 3 5,450-hp. motor-generator sets, having a combined capacity of 36,000 amperes at 320 volts, and a voltage range from 0 to 320.

Photo courtesy Westinghouse Elec. & Mfg. Co. and Inspiration Consolidated Copper Co.

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**Officers and Committees** (For complete listing see p. 71–76, January 1932 issue of ELECTRICAL ENGINEERING.)

C. E. SKINNER whose term as president of the A.I.E.E. expires July 31, 1932, outlined some of the difficulties facing the Institute and electrical engineers in general today, in his summer convention address at Cleveland. Speaking of present economic conditions President Skinner said "...there seems to be a widespread feeling that relief must come through the application of the engineering method." *p. 472–476*

PAPERS presented at the District meeting held May 4–7, in Providence, R. I., elicited the usual amount of discussion. Papers dealing with induction motors were especially well discussed. *p. 524–525*

THOSE who will spend their vacation attending the 1932 Pacific Coast convention to be held in Vancouver, B. C., August 30 to September 2, will find that the committees have spared no effort to make their visits both highly profitable and extremely enjoyable. *p. 518–519*

MEMBERS of the Institute and subscribers continue to make use of ELECTRICAL ENGINEERING's open forum, the "Letters to the Editor" columns. Discussions of a variety of topics may be found in this issue. *p. 527*

BREAKAGE of conductors on electric power transmission lines formerly attributed to crystallization of the conductor material now is charged to mechanical vibration. The first of two articles dealing with this problem describes laboratory tests made for the purpose of studying the nature of this phenomena, and means of combating it. *p. 482–487*

TELETYPEWRITER communication is used to a large extent in collecting and disseminating meteorological data along with principal airways of the United States. This service, of which a large portion is provided by the government, is used also for plane dispatching and other matters incidental to the operation of the country's airways. *p. 492–496*

NEW OFFICERS elected recently to serve the Institute for the year 1932–33 were announced at the summer convention. *p. 517*

INDUSTRIAL MANAGEMENT and engineering are twin brothers; they have developed together. So states an authority on engineering education in discussing the educational aspects of engineering and management. *p. 476–481*

BEHAVIOR of the plate and grid currents in a grid-controlled mercury-vapor tube may inhibit the proper functioning of the tube. This is one of the findings of a series of tests on a typical tube of this type. *p. 500–505*

CALORIMETER tests on a large hydro generator show that the stray losses measured under load conditions are practically the same as those measured by the conventional short circuit methods. *p. 497–500*

IMPROVEMENTS in the design of single-phase commutating type railway motors have made it possible to design simpler, lighter, and less expensive a-c. locomotives for the Pennsylvania's New York-Washington electrification than had been used previously on that road. *p. 488–492*

IN THE PAST many of the data for comparable porcelain insulators for use on electric power transmission lines seemed conflicting. A closer agreement among the different manufacturers is indicated, however, in a group of three articles covering recent studies conducted in this highly important field. *p. 505–516*

TO CALL the 1932 A.I.E.E. summer convention just concluded in Cleveland, Ohio, an unqualified success is no mistake. The technical sessions were maintained at their usual high standard; the sports events, always important parts of the summer convention, were "top notchers" as usual; many matters of importance to the Institute were considered at both the annual meeting, and the conference of officers, delegates, and members. *p. 520–523*

# The Engineer in a Changing Society

An outstanding article is presented herewith. It is the address given on June 21, 1932, by Doctor Wickenden during a special session of the recently completed forty-eighth annual summer convention of the Institute in Cleveland, Ohio. Its message is of tremendous importance to engineers and to society. —Editors.

By
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IN THE DRAMA of civilization, the engineer suddenly finds himself called from manipulating the properties in the back-scene and the wings to play a leading rôle in the center of the stage, and the public is not yet sure whether he is the hero or the villain of the piece. The old-line actors who have been thrust into secondary rôles are saying contemptuous things. "This newcomer—he is a mere upstart, with no traditions; he is a hard-minded fellow, without refined sensibilities; he reduces everything he touches to hard and fast quantities, as if the problems of life could be solved on a slide-rule and an adding machine; he cares nothing for beauty and serenity; he fills our cities with noise and ugliness and the countryside with grime and waste; he standardizes all that he touches; he makes robots out of men by day, and fondly imagines that he can turn them back into men after working hours by giving them bathtubs, radios, and cheap automobiles. This fellow is a philistine, with no love for the human spirit."

It is hard to cast the engineer of today into the mold of a hero. No modern Virgil has quite dared to begin an epic "Tools and the man I sing," but then Aeneas had plenty of time to become a legendary figure before Virgil took him in hand. Just at the moment heroes are out of fashion, anyway. The echoes of the greatest war in history are barely stilled, and not one military idol has a pedestal. Foch retires in simple dignity to write his memoirs; Hindenburg hangs up his saber and goes to work for the Fatherland; and Pershing remains the best tailored general in retirement. Shades of Wellington and U. S. Grant! Heroes are out of fashion.

Some of our contemporaries, wearied by the shocks of revolution and transition, are feeling homesick for the middle ages. They would like to see us back in the thirteenth century again, building Gothic cathedrals for the sheer joy of faith and love of beauty. That was the day for heroes, only then men called them saints. Seen from afar, what a simple and unified life that was, with no cross-purposes, no complexes, and no frustrations. Human life and society had but one aim, one ideal, one value, one goal, and that the life beyond. The attainment of sainthood, if not in this world at least in the next, was the goal of all striving. All work was religious work and every calling had its patron saint. Many of the saints seem to have won their halos by reputed services in making crops to flourish, in driving away pests or in warding off epidemics. Perhaps our scientists and inventors are 6 centuries too late. Pasteur, Lister, Edison, and Marconi would most certainly have been canonized, and perhaps even a special day set in the calendar for the veneration of Saint Henry Ford.

Geniuses, it would seem, have been growing either more rare or more commonplace under the blighting touch of science. Who in these 3 centuries since Galileo dares to measure his stature with a Moses, a Homer, an Alexander, a Plato, a Jesus, a Michael Angelo, or a Shakespeare? The essence of modernity is that progress no longer waits on genius; instead we have learned to put our faith in the processes of research and the organized cooperation of ordinary men. To the ancients the pursuit of knowledge was like placer mining—a pursuit for solitary prospectors. Nuggets of truth were found occasionally, and sometimes in a fairly pure state. It would seem that these nuggets were more often hoarded than milled into the coinage of common knowledge. Very often the nuggets were lost or forgotten, waiting a thousand years to be rediscovered. Three centuries before Christ, Aristarchus undertook to measure the distances separating the earth from the moon and the sun, and posited the earth's revolution about the latter. Shortly after an Alexandrian Greek, Eratosthenes, proved the earth to be a sphere and actually measured its diameter within a scant 50 miles of error. Yet none of this knowledge availed to keep Galileo from threat of torture and excommunication.

## SCIENCE BECOMES POWERFUL

Man began to subdue nature and to transform his world when—about 3 centuries ago—he began to mine the hidden veins of knowledge systematically, when he learned not only to recognize truth in its free state, but to separate the finely dispersed gold from the baser ore of common experience, by measurement, by experiment, by hypothesis, and by verification.

Science became powerful when it became cumulative, when observers began to keep detailed records, to publish their findings to the world, to organize co-operating groups in order to pool and criticize their experiences. Science became powerful when its gold was no longer hoarded but was coined into everyday knowledge and use.

## SCIENCE A DIVISION OF KNOWLEDGE

Science, too, owes much to the principle of division of labor. Francis Bacon, who by profession was Lord Chancellor of England, was able to claim all knowledge as his sphere in the sixteenth century. Effective science began when it passed from the occasional amateur into the hands of men who made the winning of knowledge their special function or profession. At once these men began to break knowledge up into smaller and smaller fragments, in order to pursue it more intensively. Recently ex-Senator Pepper, of our neighboring state of Pennsylvania, made this contrast between the specialism of science and the generalism of philosophy the subject of a clever epigram. Scientists, he observes, are men who learn more and more about less and less till they end by knowing everything about nothing; while philosophers learn less and less about more and more until they know nothing about everything. In any well-balanced educational program science needs the compensating values of philosophy and art, because of this fragmentizing of nature and experience.

## GROUP EFFORT, NOT INDIVIDUAL, BECOMES IMPORTANT

As science has become more dominant in human activity, the reign of genius has begun to fade. Though rich in great names, the annals of science are strikingly devoid of towering figures. Science grows by accumulation rather than by brilliant and unpredictable strokes of genius. Its victories belong to the army of patient investigators in sequestered laboratories, rather than to some rare Napoleon of the lecture platform. Its ideal is that of removing the hazards of chance from progress. The key to the technological revolution of the last century is not in individual wizardry, nor in genius appearing suddenly like a prophet from the wilderness; it is to be found in the capacity which men have developed to work in organized groups, developing their leadership from within.

It is this ideal of progress through cumulative effort rather than through genius—progress by organized effort, progress which does not wait for some brilliant stroke, some lucky discovery, or the advent of some superman, which marks the chief contribution of science to social philosophy. The results are brilliant, but they fail to satisfy the instinct of hero-worship. "Arms and the man I sing," chants Virgil in heroic meters to celebrate an age gorgeous in color and romance. The machine age leaves the poet mute, or if he does attempt a song it is in a minor key like Masefield's "Life's a long headache in a noisy street."

## SCIENCE IS NEW, MAN IS OLD

Much of our confusion about the social values of science and its technical uses appears to arise from the fact that our instincts and our circumstances have gotten several centuries out of step. We have a million years of pre-civilized experience imbedded in our nervous systems and our emotions, an experience dominated by fear, cold, want, disease, and hunger. Science and a scheme of life based on organized knowledge are new, startlingly new in terms of race experience. This whole idea of purposed and controlled progress is even newer, and as for getting machines to do work instead of muscles, so that all men may have an abundance, it is an innovation of the moment. For the sake of vividness, let us reduce the scale of race history to terms of individual experience. Instead of a million years of race development, let us think in terms of the time it takes an individual to reach the full maturity of his powers—say 50 years. On this scale how old are civilization, organized science, the idea of progress by deliberate innovation, and this machine age? It is as if *homo sapiens* had settled down from a nomadic existence to tend flocks and till the soil only 19 days ago, as if he had grown curious about the ways of nature a little after midnight this morning, had hit upon the idea that progress does not merely happen but can be deliberately speeded up by invention and innovation about dawn and had gone about the task of making machines do his work for him only as he got up from this morning's breakfast table. Little wonder that his instincts and emotions are in confusion.

A certain anthropologist has in his collection 2 primitive stone implements, which he estimates to differ in age by half a million years. One is crude in the extreme and scarcely recognizable as a tool; the other is fashioned with considerable art. They represent the pace of unaided evolution in human affairs. As an experiment, he took modern boys with no experience in chipping stone and with only the most primitive materials, taught them in a little more than 2 hours to chip out implements superior to the best work of prehistoric man. So much for the pace of progress by deliberate scientific control. Implicit in this episode is the startling contrast between the ancient idea of static society, the mediaeval idea of progress by unaided evolution, and the modern idea of purposed and controlled progress.

## PROGRESS IS A NEW IDEA

The very idea of human progress seems to have been alien to the ancient mind. Society, it was thought, lived in repeated cycles. Some genius would appear and lift life for a time to a higher level, but as he became a legendary figure, life would lapse again to its old commonplace. Rise and fall, ebb and flow, were supposed to be inherent in human experience, but the base line was fixed and unchanging. Ancient civilization was largely backward-looking. Its poets sang of some golden age, when men were as gods. Its hopes were centered in some Messiah who might restore the glories that had been lost. The mediaeval mind, it would seem, was a little more inclined to believe in progress. Mankind might be on the upward grade, but at best it was an almost imperceptible slope, and what was gained could come only by a toilsome process of trial and error. Only modern man, armed with the tools of science, has dared to believe that the welfare of human society was in his own control.

### ABUNDANCE, TOO, IS NEW

To modern science, and its ideal of cumulative progress, we must also credit the growth among men of a psychology of abundance. To the primitive mind, with the hardships of continuous want and occasional famine branded on its memory, the notion that the earth could be made to yield an abundance of goods for all her children could seem only fantastic. Stoicism represented the highest level of virtue in an age of want. Charles A. Beard speaks of his vivid first impression of the Hindu religion, as the natural expression of the philosophy of a people with no hope in this or any other world of having a square meal. If scanty resources and production forbid the satisfaction of the most elemental of all desires—the longing for food—what greater boon could man crave than emancipation for all consciousness and desire?

The ancient world looked on slavery and aristocracy as natural institutions, or even as ordained of God. They were the inevitable consequences of meager resources. To me, it has always seemed no mere coincidence that the growth of democratic ideals and institutions has moved step by step with the growth of pure and applied science. Democracy is the political and social affirmation of the credo of progress; it rests on faith in man's capacity to produce an abundance for all. Do not make the mistake of blaming today's hunger and want on men of science and on engineers. The sad dilemma of a hungry world in which farmers burn the crops for fuel, of ragged men in the shadow of mills able to turn out 3 times as many garments and shoes as the people have ever used, of a business world as much troubled with unemployed dollars as with unemployed men, all suggests that researchers and engineers have eagerly accepted the psychology of abundance, while the world of finance and of trade is still largely dominated by the economics—or perhaps better the instincts—of scarcity.

### MAN OVERCOMES HIS LIMITATIONS

Thomas Carlyle, who had a great deal to say of heroes and hero worship once spoke of man as "the tool-using animal." However Carlyle may have meant it, this is really a great tribute to man's dignity and worth. Man, alone in all nature, overcomes his own limitations. His voice is weak and can carry only a few hundred feet; but he builds an amplifier which can be heard for 5 miles, so that he may speak to possible millions. His hearing is faint, but he makes an electric ear which can detect an airplane 10 miles away. He can count about 10 to a second, but he makes an electric eye fast enough to count 50,000 times a second. If he is accurate, he can estimate lengths to a quarter of an inch, but he captures a light wave and makes it measure to a millionth of an inch. He can see 10 or 20 miles, with the light gathered by his eye, but he makes a telescope which gathers light from galaxies 100,000 light-years distant. He holds up his hand and feels no heat from the stars, but he builds a radiometer, so delicate that in comparison with the current of an ordinary electric lamp, what it detects is equivalent to a change of 2 drops a year in the torrent of a Niagara. He, himself, is a weak, inefficient machine, but he builds on one shaft a machine to supply more work than could be done by all the slaves Lincoln freed.

Only man, in all nature, overcomes his own limitations and explores the universe about him. That is what all tools are for, to overcome the limitations of men. If ever the tables are turned and machines become masters of men, civilization will be upside down. It would be folly to assert that only good can come out of discovery and invention; but it is equal folly to blame upon researchers and inventors the hardships which come as an incidental result of their work. Back of all the details of industrial economy lies half concealed a more profound issue of social utility which scientists and engineers have never directly faced. How far is it humanly profitable to push discovery and invention? Perhaps it would be more appropriate to ask "how fast" in place of "how far." Free play to the social consequences has always been taken for granted. Individuals were bound to suffer hardships but it was assumed that society at large profited immensely. The doctrine of *laissez-faire* assumes that at least a working balance will be kept between technical and moral progress. We have seen industrial technique advance with amazing swiftness, while the moral and legal controls on which the safety of society depends were being readjusted by the fumbling process of trial and error.

### SCIENTIFIC KNOWLEDGE EXCEEDS SOCIAL INTELLIGENCE

The tools of industry are in themselves neither good nor evil. Good or evil can come only out of the uses to which they are put, and this issue, in turn, depends on the values they are employed to create. We live in a day when the ruling scale of social values has gotten badly out of step with economic facts. The triumphs of physical science and our faith in the social gains from technology have made us overconfident. Have we not built up a social structure far beyond the limits of our social intelligence? The foundations, the materials and the members of this structure which were ample in a simpler day have proved unequal to the complex stresses of a technological era. Our knowledge of men and of social institutions stands today where our knowledge of material nature stood 2 centuries back. There are signs now that we may be compelled to retrace our steps for a time to a simpler social order in order to prepare for an advance movement to new and more secure ground. Civilization may not collapse, but evolution is being speeded far beyond its normal pace. A decade may see changes in the social order suddenly realized, which are in reality the cumulative result of the work of a century. The educator and the engineer both work with an eye to the future and must take the risks of forecasting on the basis of today's facts and of yesterday's experience.

## RESPONSIBILITY OF ENGINEERS INCREASES

It is plain to all that the focus of our social interests is no longer political, as it was with the revolutionary fathers; it is economic. Their passion for political rights awakens only a hollow echo in the citizenry of today. Government based on geographical representation is showing signs of bankruptcy in an age when men's vital interests divide according to their work, rather than their place of dwelling. Our parties offer us no principles; our elections are fought around persons rather than policies. Actually the farm bloc, the manufacturers' lobby and the bonus seekers stand nearer the real issues of our public life than do the Republican and the Democratic parties. Democracy, with its trust in the collective wisdom of common men, may prove to be unequal to severe social and economic stresses. Russia and Italy have repudiated it; Japan is turning away from it; and Germany hangs precariously in the balance. The engineer has never been a major force in politics; his interests have been administrative, rather than legislative. If, in the turn of evolution, government is to be recast on functional lines of representation, our profession may find its public responsibility greatly increased.

## IMPORTANCE OF AGRICULTURE

American agriculture appears to have reached a maximum phase of development and to have entered upon a phase of decline. Until the turn of the century its history was written in terms of an unparalleled expansion of acreage and of markets. We spent millions on research to make the farmer prosperous by increasing his producing power, only to bring him face to face with a blind wall of market limitations. In a period when our manufactured output per capita was doubling and mineral production increasing two and a quarter fold, our farm production per capita fell off appreciably. Farm population has been declining at the rate of a million or more a decade, until the present crisis, and there is now a threat that the mechanization of agriculture will further speed this decline. Hope of reversing this trend seems to be in 2 possible directions. One is a great increase in the use of agricultural products and by-products as raw materials in industry; the other is a return to a self-contained farm life with little dependence on money crops. We may see the story of cotton seed repeated on a vast scale. In 1860 it was garbage, in 1870 fertilizer, in 1880 cattle feed, and in 1890 table food. Today it is an industry representing a turnover of half a billion dollars a year, 40 per cent of which goes to the farmer for what was once a waste and a nuisance. Subsistence farming appears unpromising in itself, but highly promising as an adjunct to industrial employment. The slogan of tomorrow may not be "Back to the soil;" it is more likely to be "One foot in industry and one on the land." If technological and market changes continue to make jobs in industry more and more precarious, some such combination of soil and job is about all that stands between America and a fast-growing proletariat.

While purely rural living is declining, the overcrowding of our cities may also decline. Glenn Frank reminds us that in an age of steam power, it was necessary to bring the worker to the power, but in an age of electrical power we take the power to the worker. Transport by water and rail was inflexible. Town and factory had to come to the traffic arteries. Highway transport, on the contrary, seeks out the remotest hamlets.

## MANPOWER VERSUS NATURAL RESOURCES AND MACHINES

Recent advances in technology have definitely ended our traditional shortage of manpower. This may prove to be a wholly new phase in our national history. If so, the social doctrine which has dominated our politics, our education, and our industry, based on the premises that men are scarce while space and materials are abundant, that society must cherish each individual and develop his powers to the full, that industry must adopt every expedient to "save" labor but could afford to be prodigal with ore, coal, oil, timber, water, soil, and other bounties of nature, may undergo radical revision. The incentives which urged on much of our research, have shaped the objectives of invention, and have led us to the unparalleled development of the automatic machine and process in the last 3 decades may lose much of their force. Labor surplus, due to mechanical productivity, may swing America nearer to a parallel with western Europe, with its overcrowding of population and shortage of raw materials.

For a time the curve of industrial progress appeared to be an expanding spiral. Invention, stimulated by labor shortage and drawing on a vast reserve of scientific knowledge, gave us better machines; machines lowered costs, made improved products possible and thus opened up vast new markets; increased turnover provided new capital and credit for plant expansion; capital in turn subsidized research and stimulated invention; workers were displaced by machines, then reabsorbed into new forms of production and service; tasks became more specialized and craftsmanship declined, wiping out the worker's capital in his skill; the buying power of a day's work rose and created new levels of consumption; advertisers and salesmen stood by with stimulation in hand to revive a flagging market; and the cycle was expected to repeat itself indefinitely on an ever-widening scale.

It now appears that once the magic curve is broken, it is extremely difficult to reestablish it. Possibly the curve is not a spiral after all. Some of the factors may have been transients rather than constants, and the curve may have an inherent saturation range where machine economy passes into an area of diminishing returns. Technological unemployment may prove to be not only a temporary hardship to individuals, but also a cumulative process which brings a menacing train of sociological consequences in its wake. What of the mass markets on which mass production depends? What political consequences may come from the rise of a proletariat with no stake in land or in skill or in permanent employment? What if educational and welfare agencies must make their programs and budgets fit a condition where there will be little employment for the youths under 18 and only posts of leadership for adults over 50? Society may with sound justice insist that the economic burden of labor displacements be reckoned in the costs of production. Engineers contemplating the adoption of labor-saving machinery may have to include some form of social indemnity as part of the cost burden on which a profit may be shown.

## MATERIALS INCREASE IN IMPORTANCE

The moving force in the industrial revolution of the last century and a half has been the substitution of machines for muscular labor. While this force is far from exhausted, it appears to have entered a realm of diminishing returns. Thus far the substitution of artificial materials for those more or less directly obtained from nature has been a distinctly secondary factor, but one which lately has begun to assume a commanding importance. If pushed to its limits, however, this newer force can scarcely be expected to give to industry as a whole as great a stimulus as that which comes from mechanical invention, or from steam and electrical power. It may suffice, however, to afford a considerable check on any slowing down process. In any case chemistry and metallurgy are fairly certain to assume greatly increased importance in every realm of engineering.

As a result of this growing interest in synthetic materials, the deadliest competition of today is not so much between concerns as between products. Research has been made to serve industry as a weapon of attack and of defense. Large concerns which can distribute their risks over a wide range of products and which can afford heavy expenditures for research, appear to have the best prospect of survival. The entrance of industry into the field of research marks the triumph of a new technique of invention. The philosopher Whitehead points out that what was new and peculiar to the nineteenth century was its technology. The art of writing he regards as a greater invention than the steam engine, but one which required a thousand years against a hundred for the engine.

As a matter of fact much of the earlier history of invention is one of crude practical innovation, followed—and often at long intervals—by the refinements of scientific research. Of late we have begun to reverse the order and to close the gap of time. In the modern industrial laboratory this time lag is tending to disappear entirely. Today's research becomes tomorrow's invention and the day after tomorrow's merchandise. Three decades ago industry had a veritable mountain of unused scientific information at its service. Today that margin has largely disappeared. If invention is to give industry another such impetus in the next 3 decades our research efforts must be redoubled.

## CONDITIONS MAY BECOME MORE STABLE

An era of stable rather than increasing population appears to be at hand. In the early decades of the last century our population was growing at 4 times the world rate, and in the late decades at double. The prospective scarcity of land and natural resources was heavily capitalized and vast fortunes were accumulated from this almost effortless wealth. The tempo of agriculture and industry was adjusted to rapidly expanding markets and rising wealth. Just when this growth began to slacken, the world war gave production an immense but temporary impetus, which has complicated the process of readjustment. The shortage of land and natural resources has failed to arrive; both show signs of having been heavily overcapitalized. The economic life of America is apparently becoming more nearly parallel to that of Europe where the turnover of trade rather than the unearned increment is the chief source of accumulation. The effect of this change on our national habits of philanthropy is an interesting subject for speculation. Will our educational and welfare institutions continue to enjoy private bounties on the scale of the past? Possibly not.

## PROBLEMS OF YOUTH INCREASE

To the educator the changes in the age distribution of a population which is in process of becoming stable are even more significant. If we go back to 1850 we find more than half the population of the United States under 20 years of age, and barely one person in 11 a mature adult over 50. The actuarial prospect for 1950, when the curve has flattened out, is that about a third will be under 20 and fully one-quarter over 50, in short that the ratio of mature adults to young people will have increased 4-fold in a century. In 1850, youth was abundant and at a discount, maturity was scarce and commanded a premium. Maturity is now becoming abundant and youth more scarce, with a reversal of the scale of values. The social consequences are evident on all sides. Leisure is being transferred from youth to maturity. The decade from 20 to 30 is becoming less available for adventure and experimentation. Settling down at 30 is beginning to involve risks of never making permanent connections at all. The age level of life's most severe competitions is coming down. More and more, the long and costly sequence of school, college, professional training, and apprenticeship running into the late twenties is being called into question.

If stable population and surplus manpower affect America as they have already affected Europe we may see social strata becoming more permanent, the carry-over of wealth from one generation to another assuming greater importance, a sharper cleavage forming between education for citizenship in general and that for highly intellectual pursuits, greater concern to fit young people efficiently into the economic system, more of education transferred to a continuation period running parallel to early employment, and more of an effort to create and diffuse a national culture concentrated on the growing leisure of middle and late adulthood. These changes seem to the writer to confirm the wisdom of an educational program which brings the great body of our young engineers into the normal relationships of the industrial world at the age of 22; they also emphasize the need to provide much more generously than in the past for continuation education for graduates.

## SECONDARY EDUCATION

The scope of secondary education is being greatly extended and its functions widened. Up to the present the high school has taken only an incidental part in the occupational sorting and guiding of youth. In the early future it may have to carry the major part of this responsibility. The states have been steadily advancing the age limits of compulsory school attendance. Meanwhile commerce and industry have had less and less to offer young persons seeking employment under the age of 18. The highly subdivided tasks open to these untrained beginners usually have little training and exploratory value to those in search of careers. The school has no choice but to hold all its pupils through the early stage of adolescence, and to provide them with the means of finding out their occupational interests and of measuring their capacities against the world's work. The surface of this problem has scarcely been scratched. The number of recognized vocations is said to exceed 30,000 and a majority of those in industry, at least, are so far removed from the elemental experiences of youth that a young person cannot easily visualize them or by imagination project himself into them.

The overwhelming magnitude of this task of social and occupational adjustment, involving each year an army of 2¼ million recruits to the active duties of life, has threatened to overshadow the intellectual functions of the secondary schools, and to dilute the education of young people of intellectual tastes and gifts. Schools, at times, have seemed to resemble department stores where all kinds of merchandise are considered equally important and the customer is always right. Within the last decade, however, this equalitarian movement has apparently reached its limit.

The engineering profession has much to gain from a clearer separation of the intellectual side of secondary education from its work of social adjustment. For its own recruitment it wishes students who are soundly grounded in the exact sciences, languages, history, and civics, and are accustomed to the rigors of solid intellectual work. If, as, and when the program of work now contemplated for the junior college can be consolidated with the present secondary course and completed by students of intellectual tastes and gifts at the age of 18 or 19, the engineering colleges will readily accommodate themselves to a more advanced level of entrance, and a higher degree of student selection in advance.

The certain result of greater segregation of the intellectual phase of secondary education and its gradual extension will be a greater emphasis on the exploratory and vocational phases for the vast majority together with a rising demand for continuative technical training leading up to the more practical pursuits in business and industry. There is apparently no need to increase the number of engineering colleges, but rather to make their standards more exacting and their professional aims more pronounced. As a complement to these colleges, there is unmistakable need for technical institutes and continuation schools in large numbers, with flexible levels of admission and with programs of work closely related to particular industries and occupations.

## NEW PROBLEMS FOR CAPITALISM

To return for a moment to broader social movements, we may observe that democratic capitalism, with its strong individualistic ideals, is being challenged by its own economic dilemmas from within and by rival systems in actual operation from without. Capitalism rests on the principle that what matters most to society is the use a man puts his money to after he has acquired it. It assumes that the next generation will need to consume more than the present one, and that whatever surplus of wealth exists can best be entrusted to persons who will not consume it, but use it to augment the means of production. For this service incentives are offered and rewards paid. In an era when both the population and the standard of living were rising rapidly and especially in the pioneer life of a virgin continent, this principle has been socially fruitful through its stimulus to individual initiative and thrift. We may now be at a turning point. Examples of a socially wasteful unbalance between producing and consuming power have multiplied in the post-war period in agriculture, mineral production, and manufacturing alike. Machine technology, with its seemingly limitless capacity for increasing production, has apparently accentuated this loss of equilibrium. The result has been called a dilemma of thrift. The capital and credit structure built up on producing capacity may prove to be larger than the buying power of society can sustain in the presence of forces which tend to diminish the volume of employment available. If so, capital may find it difficult to obtain new outlets and industry may be forced to distribute a larger proportion of its income in forms that directly augment consumption, that is, as wages and cash dividends. Society may deem it expedient to limit the plowing back of profits to increase plant capacity. It may also find ways to limit the mechanizing of production, rather than to have an unemployable proletariat growing on its hands.

## ENGINEERS WILL NEED SOCIAL ORIENTATION

Engineers, on whose analysis and judgment hang the risks of future investments and plant extensions, will have new social forces with which to reckon. These new forces will influence not only their more philosophic reflections, but also the arithmetic of engineering economy as well. The current social changes point inevitably to an increasing degree of social control in economic processes. The day is probably past when society will wink at socially wasteful processes of making money, if only it is invested prudently after it is made. The issue is not so much one between capitalism and socialism as between society and the individual, between a controlled economy and one based on *laissez-faire*. The engineer of a generation hence will not only have a wider range of scientific tools at his disposal, but he will almost certainly be guided by economic premises in which broader conceptions of social expediency will prevail than in the more individualistic past. He may not be an employee of the state, but he will work under a wider range of public regulation.

The engineer of tomorrow will be, as he is today, a social pragmatist, one who accepts the existing order provisionally and works within it, whether it be *laissez-faire* capitalism, Marxian communism, or Italian fascism. He will accept any system, as far as it works. This attitude is fairly inherent in his professional function and duty. If, however, the engineer of tomorrow aspires to be a molding force within the industrial system, he will need a more profound and more critical understanding of economic forces and of social values than that which sufficed for an era of rugged individualism. Social orientation bids fair to rank equally with scientific discipline as an essential basis of his training.

## Civilization Must Go On

The first duty of the engineer in a changing society is to keep civilization running. As in the theater, the show must go on. If, as some critics urge, science and machinery were abandoned and a few hundred thousand engineers were to quit for good, the whole structure of society would come down around our ears and when we pulled ourselves out of the ruins the life around us would resemble that of rural Russia under the Czars. By keeping society going, the engineer is giving evolution a chance to work.

## Guesswork Must Be Stopped

The fundamental job of the engineer is to take the guesswork out of economic life as rapidly as scientific knowledge will permit. So far he has succeeded brilliantly with process and products, and this success is opening new doors. His next job will be to take guesswork out of the use of products and resources, out of their distribution as well as their production; also to take guesswork out of the use of capital and of manpower. The functions bring the engineer into more vital contact with what are called, somewhat optimistically, the social sciences. Our knowledge of man and of social institutions stands today about where our knowledge of physics and chemistry stood 2 centuries ago. Until a better equilibrium between technical and social knowledge is built up the safety of society demands a type of leadership in industry and the technical professions which is highly sensitized on the side of social welfare and ethics. It is the business of the engineering profession to supply this leadership. We constitute the dominant professional group in the industrial world. As a profession, society has a right to expect of us a certain disinterestedness of spirit, a devotion to truth wherever it may lead, and a conscious dedication to the good of society as a whole. We are expected to have the long view and not to live merely from balance sheet to balance sheet. We have a tradition of ethical accountability. We stand for the rule of science rather than intuitive guesswork. We are not doctrinaires and revolutionaries but have our feet on the ground of fact and experience.

## The Engineer's Social Responsibility

It is a significant fact that every revolutionary movement in the world of today has tended to augment rather than narrow the engineer's sphere of social responsibility. This has been true in Russia, in Italy, in Spain, and in China. The concern of educators, in view of the present revolutionary outlook, is not so much to make our graduates more proficient in details, whether of technique or of management; it is to develop men who are able to deal in a more statesmanlike manner with the major economic and social problems of a technological era. As the writer sees it, the solution of this problem involves more than adding this or that to the curriculum or keeping the boys a year or two longer in college under the guidance of subject matter specialists. It involves a more organic conception of the whole process of recruitment, training and development within the profession—one that transcends the details of the arbitrary or accidental divisions of schooling and apprenticeship, the regulations of the licensing boards, and the rules of eligibility for the several grades of society membership.

It is encouraging to note that the joint movement now taking form among our national bodies for a scheme of professional certification looks in that direction. What is contemplated is a scheme of educational guidance that reaches down into the secondary school, bridges the college period, and covers the early years of professional activity, and which has as its objective a comprehensive appraisal of educational attainment at a mature level, as a qualifying standard for certification into the profession.

Many college men hope that this broader view, with its increased emphasis on further education after college, may so relieve the pressure on the undergraduate curriculum that a more profound grounding may be given in both the scientific and the societal groups of studies. Replacing this ground work with elementary management subjects will not solve the problem of a more adequate professional education. It may supplement it, and in a very valuable way. Courses in preparation for the management of industry are a legitimate adjunct to professional training in engineering, but if we are to remain a profession in the corporate sense and not become merely a fraternity of managers and executives, we must maintain the primacy of the sciences and of the philosophy of social institutions and relationships. We may keep our fellowship open to the administrative as well as the technical worker, but the nucleus of the profession must always be an intellectually qualified, scientifically grounded, socially intelligent body of men, bound by a strong code of ethical responsibility and devoted to an ideal of disinterested service, rather than the expediency of the next balance sheet.

# The Institute and Its Members—Our Problems and Our Responsibilities

**Many points of direct interest and prime importance to members of the Institute, individually and collectively, were discussed by President Skinner in the annual address before the summer convention. That the entire membership may benefit accordingly, the full text of the address is published herewith. ——The Editors.**

By
C. E. SKINNER
PRESIDENT A.I.E.E.

THE AMERICAN Institute of Electrical Engineers is the youngest of the 4 major national engineering organizations of the United States. Its existence closely parallels the growth of the electrical industry not only of this country, but of the world, and its printed proceedings and transactions form the most important existing records of the development of the electrical art and industry of the country. These records cover a wide field, from the announcement of outstanding inventions and scientific discoveries in the electrical art to the commercial applications of electrical devices to every possible use in industry and society. The membership of the Institute from a very small beginning in 1884 has grown to a maximum of more than 18,000. The Institute's open forum for the discussion of problems, the announcements of discoveries, the work of its standards committee, and the work of its technical committees have been potent factors in the phenomenal development of the use of electricity throughout the nation. Electrical engineers interested in every possible phase of the art have given their time, their energy, and their best efforts to the work of our Institute.

The presidential addresses of my predecessors have covered an extremely wide range of subjects. They have dealt with abstruse scientific and technical problems. They have dealt with the status of the industry at the time the address was given; they have dealt with the idealism of the engineer, with pleas for recognition of engineering as a profession, with our relations to other engineering societies, and with many other subjects. I wonder how many members of the Institute have read and studied these addresses, other than the outgoing president who is faced with the constitutional requirement that he deliver an address and who, therefore, is interested in what his predecessors have said. Some of the finest things ever said before this Institute may be found in these addresses and I despair of being able to live up to the standards set by them.

From time to time the President of the United States issues a message intended primarily to call the attention of the Congress and of the people to the condition of the nation. In like manner, perhaps I can do no better than to call the attention of the Institute's membership to the state of affairs with which we as engineers are confronted. This requires that I outline a number of things which may seem to be more or less unrelated, but all of which I believe have a bearing on the present conditions and on the future of the Institute, and some of which are of importance to all engineers.

## ACTING NATIONAL SECRETARY APPOINTED

The Institute suffered a severe loss during the year in the death of its national secretary, Mr. F. L. Hutchinson, who had served the Institute with ability, loyalty, and unflagging energy for a period of more than 28 years. The many appreciations of Mr. Hutchinson and his work that have been received indicate the high opinion in which he was held, both by Institute members and by others with whom he had come in contact. Some of these expressions have appeared in ELECTRICAL ENGINEERING. The Institute's board of directors has given earnest consideration to the selection of Mr. Hutchinson's successor. It found itself in the fortunate position of having in Mr. Henline, assistant national secretary, a man familiar with Institute affairs and with the many duties of the office of secretary. As previously announced, Mr. Henline has been appointed acting national secretary as of June 1, 1932. Mr. Henline comes to this position at a difficult time brought about by a decrease in membership and revenue arising out of our disturbed economic conditions. The situation demands the most rigid economy in the conduct of the affairs of the Institute, with very little decrease, if any, in the amount of work required to carry on Institute affairs. I bespeak the loyal support of every member of the Institute for Mr. Henline in this new and responsible position.

## BALANCING THE BUDGET

It will not be a surprise to any member of the Institute for me to say that there has been a considerable net decrease in our membership and in our income during the last year or two. Many of our members, as in every other walk of life, are unemployed and many of these are not in a position to pay their dues to the Institute. There also has been a substantial falling off in the revenue from advertising in ELECTRICAL ENGINEERING. Unfortunately, decrease in membership does not automatically decrease in proportion the necessary expense to serve the remaining membership. Consequently, the executive office, the board of directors, and the finance committee have found it necessary to make critical studies of every possible economy in order to maintain the service which every member has a right to expect from his membership. But, in spite of their best efforts, there will be a deficit at the end of the current appropriation year, and the following year may be still more difficult. Fortunately, through wise management during the past, there is sufficient reserve to meet the present deficit. However, a deficit cannot be continued indefinitely, and special studies are being made on ways and means of balancing our budget. Unlike our political friends, we cannot levy additional taxes. Consequently, budget balancing must be brought about through economies and through accessions to our membership. We must provide more service to our members, if this be possible, and at less cost.

## SECTION AND BRANCH INTEREST

During his administrative year your president has visited many Sections and Branches of the Institute. This has entailed a great amount of travel but it is hoped that the time, energy, and money have been well spent. It was most heartening to find in every Section and Branch visited an enthusiasm for the Institute and its affairs. An attempt was made to place before these far-flung units some of the problems of the Institute, particularly those in which they are vitally concerned. Special emphasis was placed on securing the cooperation and adherence of the younger members of our profession, and of the benefits which always follow their participation in Institute affairs. The arrangement of programs particularly adapted to the specific interests and needs of each local group was urged. This has been done to a very large extent in the past by these groups but no doubt even more can be done by careful planning in the future. The decentralization of Institute management and affairs by giving a large degree of autonomy to Districts, Sections, and Branches, makes it desirable that national officers of the Institute visit them from time to time. It has been an inspiration to your president to meet with the outstanding groups of engineers that compose these units scattered throughout the United States, Canada, and Mexico. I found no greater enthusiasm for, or loyalty to, the Institute than in the 2 Sections visited in Canada and the one in Mexico.

The committee on education has given loyal service to the Institute during the year and has been doing what it can to aid at this time when so many of the graduates of the electrical engineering departments of colleges and universities find it difficult, if not impossible, to secure employment. A very few years ago graduates could select any one of several positions offered. Today there are but few positions available, and many graduates of a few years ago are now hunting for jobs. In a recent radio address a prominent speaker congratulated the graduates of today on facing a time of adversity which brings out the very best that there is in men and which will be of inestimable benefit to them in their future careers. There are some definite records showing that graduates in times such as these have gone further, on the whole, than those of better times when positions were easy to secure and easy to hold. This should give some comfort, encouragement, and renewed determination to the engineering graduates of 1931 and 1932. In this connection I would like to second the recommendation made by a prominent educator, that recent graduates who are unable to find positions carry their education further, either by specialization in their chosen line or in business courses, if such additional schooling can be arranged. Such training will be of value in whatever field the engineer may find his life's work.

## THE ENGINEER IN BUSINESS

During recent years undue emphasis perhaps has been placed on the desirability of a business career for engineers. This undoubtedly has resulted from observation of the outstanding successes of many high executives who are engineering graduates and who have had engineering experience. In spite of what will be said later in regard to the engineer taking his place in the councils of his community, the state, and the nation, which more or less presupposes training on broad cultural and business lines as well as in engineering, it is hoped that too much emphasis will not be placed by educators and others on a business career for engineers. The future undoubtedly will require for research, design, and construction, many highly technically trained engineers, who will find enduring satisfaction in work of this kind. Certainly some business training should be no handicap to the engineer, regardless of what his life work may be. In the future as in the past, men of engineering training undoubtedly will find high places in business administration, but also there will be outstanding careers for men who devote their lives to the more or less strictly technical side of engineering.

I would like to record here a specific recommendation which I have made to the chairman of the committee on education. This suggestion is that outstanding papers by students be repeated at other institutions when 2 or more Branches are within relatively easy travel distance of each other. Among the more than 1,000 talks and papers given by students during the year there are many that justify delivery before wider spread audiences and this would be accomplished by the adoption of the suggested plan. Such a plan should be a stimulus to authors and give those who are so fortunate as to be selected an invaluable experience, not only in writing and delivering papers, but also in meeting the criticisms and suggestions which undoubtedly would come from the delivery of such papers to groups in rival institutions.

## PUBLICATION POLICY

Two years ago the publication committee of the Institute concluded a searching inquiry into the question of our publications. As a result of this inquiry and recommendations coming out of it a very considerably modified policy was adopted, particularly with regard to our monthly publication now called ELECTRICAL ENGINEERING, now 18 months old in its new form. In my visits to various parts of the country I have heard a great deal of praise for this publication and extremely few criticisms. These criticisms come mainly from those who believe that ELECTRICAL ENGINEERING should confine itself strictly to technical matters and not include any commercial or so-called popular material. It should be remembered, however, that the membership of the Institute embraces individuals interested in every possible phase of the electrical art, from the most abstruse mathematical conceptions to the most common applications of equipment and devices in our daily life. Catering to this widely spread interest is no easy matter, but I feel personally that the editors of ELECTRICAL ENGINEERING in cooperation with the publication committee have attained an enviable success with our national magazine, and have constantly improved it. It may be of interest to our members to know that during the past year we have printed more than 1,000 pages of text matter in ELECTRICAL ENGINEERING, or, in our monthly edition of 23,000 copies, a total of more than 24,000,000 pages for the year. In our TRANSACTIONS we printed more than 1,700 pages of text matter in an edition of 5,000 copies, or a total of approximately 9,000,000 printed pages. This compares very favorably with the amount of literature put out by the other national engineering societies. Also our expenditure for publications per member and per dollar received from dues is very well in line with the equivalent expenditure by the other societies.

## HISTORY SHOULD BE WRITTEN NOW

At the 1932 winter convention in New York, I suggested that possibly the time had come to consider the writing of a comprehensive history of the Institute and of electrical engineering, particularly with regard to the formative years of the industry. This suggestion has evoked considerable interest and, as a result of several communications and suggestions, the board of directors authorized the appointment of a special committee to consider this subject and to report on the possibility and feasibility of such an undertaking. This committee consists of Dr. W. J. Foster, Dr. F. J. Sprague, and Dr. C. F. Scott (chairman). This committee has given some study to the question, but as yet has not presented a final report. A preliminary statement now in the hands of your president brings out several important suggestions, one or two of which I am quite sure the committee would be glad to have me emphasize here. Naturally, the task of writing a really comprehensive history is a large one and undoubtedly would result in the equivalent of an encyclopedia on the subject. The committee believes that one of the things most desirable to accomplish at the present time is to procure as much source material as possible from the pioneers who were a part of the great industrial drama of electricity. It is suggested that since the semi-centennial of the founding of the Institute occurs in 1934 it would be fitting and appropriate to have historical papers on the subject available by that time. I would like to urge those who are in position to do so to undertake the writing of such papers dealing with the specific phase of the subject with which each person is most familiar. Even a few pages of facts would be of value to our historians. The TRANSACTIONS of the Institute and the files of the electrical trade press contain much of the technical material that will be required in the construction of the history which I have in mind. However, these papers contain but little of the human-interest stories which would go so far to make such a history really readable. They give little or nothing of the aims and aspirations, the trials and reverses, or the personalities and rivalries incident to these early struggles. Very few of us are fitted to write a story in finished form as we would like to see it appear, but there are few who could not put down in simple language that part of the story with which each is familiar and which, if filed with the Institute, would become of inestimable value in later years for the "Prescott" or "Motley" who becomes the eventual historian of the rise of the electrical industry. I would like, therefore, to urge the writing of as many biographies and autobiographies as possible even though these may never appear individually in print. Future generations would indeed be greatly enriched by having such documents in the archives of the A.I.E.E. as source material. Outstanding examples of such documents are the biographies of Dr. John A. Brashear and Mr. John Sweet, and the autobiography of Mr. B. G. Lamme.

## AMERICAN ENGINEERING COUNCIL

Several previous presidential addresses have stressed the responsibility of the engineer as a citizen and the desirability of engineers bringing to bear on national and civic affairs the training and point of view that have made engineers so successful in their own fields in the past. Certainly at no time in our history has clear thinking, honest fact finding, correct deductions from these facts, and unbiased recommendations based thereon been so necessary as at present. Our amazing material progress during the last 50 years is due in large measure to the work of engineers. Whatever the causes that have resulted in the present conditions, there seems to be a wide-spread feeling that relief must come through the application of the engineering method. The American Engineering Council, of which the American Institute of Electrical Engineers is one of the constituent members, for many years has been endeavoring to help and guide in those larger problems which are beyond the limitation of any one national or local engineering society. Council has been endeavoring to give unbiased, constructive advice in national affairs which directly affect all engineers.

Outstanding studies by Council that have been completed, include "Waste in Industry," "The Relation of Safety to Production," and other studies. The most important study yet undertaken is now under consideration, namely, "The Balancing of Production, Consumption, and Distribution in Industry." It is expected that Council will divide this project into several units and, with the best talent that can be obtained in engineering circles cooperating with other interested agencies, undertake to arrive at definite conclusions in regard to some of the questions which have so disturbed the country, and even the world during these depression years. The Institute through its adherence to the American Engineering Council and to the Engineering Foundation is a party to and a supporter of this very great and worthy enterprise. It is hoped that the fact-finding method of the engineer, working with others interested, will result in the accumulation of sufficient real data on which economists, business men, and government agencies may base future action to prevent unduly wide fluctuations in the business cycles of the years to come.

The American Engineering Council has been fostering the organization of state councils along the same general lines as the organization of the American Engineering Council with the object in view of having such councils take part in state and local affairs in a manner similar to that of the American Engineering Council in national affairs. Such councils already have been organized in several states and your president, in his visits to various parts of the country, has been strongly urging the organization of these state councils. It is especially desirable at this time that such local councils study and endeavor to guide such state and municipal legislation as affects engineers and engineering, particularly as the cost of government in so many lines has been mounting by leaps and bounds with many projects proposed that are either unsound or unnecessary. Certainly no one is more competent to advise on engineering matters than are engineers themselves, and their advice will have weight if and when they are organized and when they advance arguments and opinions from the unbiased result of fact finding and not colored by self-interest. It is believed that engineers as a body are perhaps in a better position through their training and experience to divorce themselves from such self-interest than any other class of citizens.

## ADVICE DURING FINANCING OF PROJECTS

During the boom years preceding the crash of 1929, many securities were sold to the public covering projects some of which had been condemned as unsound by prominent and reputable engineers. There were perhaps more of these projects in which such engineering advice was neither asked nor desired. Perhaps it may be admitted that some projects passed upon by engineers have proved to be unsound, but it is quite certain that sound engineering advice even during the boom days, if arranged for and followed, would have saved our citizens many millions of dollars now tied up in more or less worthless paper. The American Institute of Consulting Engineers for several years has been endeavoring to have investment bankers of the country secure advice from reputable independent engineers on projects being financed. This seems particularly desirable in connection with those projects for construction work in foreign countries financed by bond issues floated in this country. We are told that this practise has been generally followed by British financiers in making foreign loans; not only do they secure preliminary surveys and advice, but they usually have a definite follow-up after the loan is made to insure that the money so loaned is efficiently used for the project for which the loan was made and that the project is properly administered during the life of the loan. The wisdom of this recommendation seems so obvious that its desirability should not be questioned. Its omission has been disastrous to many who purchased such securities. While electrical engineers perhaps are less involved in matters of this kind than some others, yet undoubtedly electrical engineers have been and will be called upon for such surveys and it should be increasingly the practise of every investor to make sure that engineering and construction projects be so reported on and approved by independent engineers of the highest reputation for honesty and good judgment, before such investments are made.

There is a more or less constantly increasing number of states passing laws requiring the registration of engineers who practise within the commonwealth. This registration usually is required of engineers who undertake work in which the public health or safety in any way is involved. In my visits to various Sections, I have urged, and I again wish to emphasize, the importance of state engineering councils seeing to it that, so far as possible, proposed legislation for the registration of engineers be uniform, reasonable, and satisfactory to all parties at interest. This can be done only in cooperation with other national and state agencies when such legislation is under consideration.

## GOVERNMENTAL PROBLEMS

The past few years have seen an enormous increase in the cost of government—national, state, and municipal. A very large proportion of the taxes collected for this expenditure is levied on organizations, facilities, and products with which engineers have had much to do. As these tax burdens become more and more onerous, engineers, along with all other citizens, have an increasing responsibility in endeavoring to see that taxes are reasonable and that monies so collected are efficiently spent. For many years engineers have been endeavoring to secure in the national government the consolidation of public works of various kinds now carried on by many unrelated and uncoordinated groups. The American Engineering Council has urged consistently the legislation necessary to accomplish this purpose. As Secretary of Commerce, Mr. Hoover strongly advocated the consolidation of such work under the direction of a highly qualified executive. As President he has repeated this recommendation in a message to the Congress, and there is some hope that legislation soon will be enacted that will attain at least a part of the objectives so long advocated by engineers. The lack of such coordination undoubtedly has cost us much money, and has had its influence on the increased taxes which have been levied from time to time. Also, we are only too familiar with waste and extravagance, and even more serious problems involved in the handling of public works. I believe that organized engineers can do much to better conditions in those places where there is inefficiency, lack of coordination, and wasteful extravagance. They should join also with their fellow citizens in demanding honest administration under efficient leadership in all the affairs of those who govern us, and particularly those who are responsible for expenditures in which engineering has a part.

I have wandered, perhaps, rather far afield from the special interests of the American Institute of Electrical Engineers and its members, but I wish to emphasize as strongly as I can the point that electrical engineers—indeed all engineers—have in addition to the loyalty which is due their national organizations: a responsibility to their fellows, to the state, and to the nation. These responsibilities can be discharged only by engineers taking an intelligent and active part in all those affairs which affect them and their fellow citizens. The electrical industry in the past has had an outstanding part in the prosperity of this nation, giving its citizens facilities, comforts, and conveniences, such as never before had been known in any time or in any land.

In spite of the many difficulties and inefficiencies which surround us, we live in the finest country in the world. I am optimistic that we will be able to follow the example set us by our fathers and go forward to better government, higher ideals, better living conditions, and equal opportunities for all.

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# Educational Aspects of Engineering and Management

By R. E. DOHERTY
MEMBER, A.I.E.E.

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**In view of clear trends of experience—of the movement of engineers into management—shall we conclude that technical engineering has proved to be an effective and sufficient training at college for those who may later enter the field of management? Or, shall we consider it necessary to modify radically all engineering curricula in order to prepare men *primarily* for management? Or, again, and from the same experience, shall we plan separately for each? And, having answered this, what should the plan be?**

THE GENERAL SUBJECT of engineering education has had searching and extensive study during the past fifteen years. Thus, there now exists a prodigious mass of material in all stages from raw data to carefully thought out conclusions and recommendations. As one attempts, by casual study, to form a rational opinion regarding educational policy as it relates to engineering and management, one is likely to become lost. At least this was the writer's experience.

A careful study therefore was undertaken of the new facts, their historical setting, and of the basic views underlying prevalent thought. From the perspective thus arrived at, a future educational policy, which seems appropriate to the writer, was framed. Since there are doubtless many others interested in this problem who have experienced a similar confusion in the face of conflicting opinion and the great tonnage of undigested data, it seems in order to present this study. There is one phase of the general problem which does not seem to have been considered seriously in previous studies, and that is the practicability of an effective training for general management in non-technical industry by other subject matter than technical engineering. This possibility is recognized in the present study.

## FACTS

The first step in the study was to ferret out and compare the major, relevant facts from the various surveys. The summary facts thus indicated, which apply certainly to mechanical, very probably to elec-

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Essential substance of a paper (No. 32-75) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20-24, 1932.

trical, and possibly to most other engineering graduates, are as follows:

1. About one-half of all such engineering graduates by the time they have reached 40 years of age, have gone into industrial work primarily executive in character. These include two approximately equal groups:
   a. Those whose duties have *required* a substantial *technical engineering knowledge.*
   b. Those whose duties have not required such knowledge.
2. Only about one-quarter of electrical and mechanical engineering graduates have remained past 40 years of age in purely technical engineering work, involving practically no executive responsibility.
3. The rest, or roughly one-quarter, have gone ultimately into work such as teaching, selling, and consulting, all of which involve dealing with people.
4. Those who have gone into work involving executive responsibility (group 1) have, on the whole, received greater financial reward than those (group 2) whose work has not involved such responsibility.
5. Those in *general* management (group 1b) whose duties have been entirely administrative and practically non-technical have, on the whole, received much greater financial reward than any other group.

Three extremely important facts of general knowledge might be added:

6. Practically all college graduates, whether engineers or not, that have become successful in management have learned all they have known about it in practise. Formal college training in management, in the general sense, has existed only during recent years, and in only a few institutions. But it is steadily increasing.
7. Practically all engineering graduates, whether they have gone into some form of management or not, have encountered those human relations which are inevitable in the cooperative enterprises in which engineers engage.
8. The great technological progress of the last half-century has been based, first, upon the extension of scientific knowledge by scientists; second, upon the careful and rational application of this knowledge to the solution of practical problems by engineers; and, third, upon the organization by those in management of capital, physical facilities, and men for production and distribution.

## IN RETROSPECT

Industrial management and engineering are twin brothers; they have developed together. During this development, both industrial management and engineering naturally experienced a correspondingly extensive metamorphosis. The range in responsibility and in requisite talent, ability, and knowledge was multiplied a thousand fold. This extension of industry was upward, fan-like. The small factories and machine shops continued, but there was also tremendous growth both in size of organizations and in range of products in the expanding industries. This two-way growth necessarily demanded not only a commensurate increase in level of ability to handle the more complex management problems, but also a corresponding increase in technical knowledge and skill. In this expanding industry, including even those branches of non-technical character, the problems of both management and engineering called for less and less guesswork, and more and more rational treatment.

Under these conditions of growth there happened the thing which might have been expected. Practically all the conditions were favorable for the engineer to be called to management positions. He was geographically on the job; his distinguishing character stics—a scientific attitude of mind and method of approach—were among the foremost requisites; and, moreover, he was vitally interested because he not only understood the processes and the products, they were his creations! Hence by normal growth and evolution many engineers have come into administrative positions.

What has been the past relation of education to management? To what extent has engineering training been appropriate and adequate for management; to what extent, essential? Formal college training in industrial management is of recent origin, and hence has had very little, if any, influence in determining the present personnel in management. However, the character of engineering education undoubtedly has influenced it; how much, relative to the influence of other existing forms of education, is not altogether clear. How appropriate engineering training has been for those management positions for which technical knowledge *per se* has not been a requisite, either directly or as a stepping stone, is largely a matter of opinion. Only this is certain: to the extent to which a quantitative method and a scientific attitude and approach are requisite or desirable in management, engineering training is highly appropriate.

In relatively recent years there has been a growing recognition, in the educational policy of engineering colleges, of the all-pervading fact that the majority of engineering graduates have gravitated ultimately to some form of management. This recognition largely has taken the form of adding appropriate electives to the regular engineering curriculum, and in setting up new courses under such headings as industrial engineering, engineering administration, etc., in which the essential core has been engineering.

But there also has been a rapidly growing philosophy which would not recognize the essentiality of *technical engineering* subject matter in college preparation for general industrial management. It holds that a scientific attitude and rational method of analysis, which are recognized both as essential and as characteristic of engineers who have succeeded in management, can be developed on some subject matter other than engineering. This general idea has not yet taken full-fledged practical form, to the writer's knowledge, unless some of the business administration courses are so regarded; but it is being reflected in the gradual deletion of technical engineering matter from such courses as mentioned above, and the substitution of general management studies. So the presumably more direct and certainly less exacting college approach to management gradually is being set up.

The financial reward for technical leadership has been less than that for general managerial leadership. According to the statistics, the man who has been able to "run" things—to coordinate human activities effectively and to judge soundly—toward definite objectives has been valued more highly by leading executives than the man whose natural talents have been in a technical vein. Moreover, according to the facts, even those who could manage men and things in technical activity have received less financial reward than those in "general" management, in which technical engineering knowledge *per se* is either not essential or altogether secondary. Going still further, those who have remained in purely technical work with no executive responsibility have been the most poorly paid. On the face of it, then, it would appear that in some fundamental way, mere association with technical matters relegates one to a lower stratum in financial reward.

However, that it has been so in the past should not be accepted as the establishment of an eternal fact. Random play of tremendous forces out of equilibrium have been the order of the day and we must be wary in drawing conclusions from experience of such a character. Nevertheless the clear implication is that something is wrong; technical engineering leadership has played too important a part in the past and obviously will be too much needed in the future to be overlooked now and smothered into insignificance under our intense enthusiasm for industrial management, which it largely created. It is not a question of merely giving such leadership its due; simply we should be stupid trustees, indeed, to the next generation if we created a problem for it by letting the present trend slip ahead unabated. Our first problem in this connection is to try to understand the past better. It is complex enough, but a thoughtful review does indicate, here and there, a rational thread running through it all.

Supply and demand, as it relates to the present subject, seems to be one such thread. In the mad rush ahead there has been a greater relative scarcity of managers, for whom no formal college training facilities had existed, than for technical leaders, for whom such facilities had been abundant. But scarcity for that reason, it should be observed, was only an accident; it was not a scarcity of natural management-talent.

If much of the best brains turned to management and, moreover, if there yet continued to be a scarcity of management ability, it is not at all surprising that this should be reflected in financial reward. By and large, if those who entered management could do the technical work the others were doing and were also capable of managing, were they not more valuable?

Engineers who have remained in purely technical work—about one-quarter of all engineering graduates—have been poorly paid relative to all others. This probably can be justified. They have learned how to make certain routine calculations, drawings, or tests, or to operate some machinery, and they do these things day after day in a routine and satisfactory manner. Their work is important—indeed essential—but a four-year college education is hardly a necessary prerequisite. Those who have remained in such positions, for the most part, have not possessed the requisite qualities of a successful engineer; and, doing the work merely of a trained technician, they have been paid accordingly.

However, there is one element in this financial reward matter which does not fit in so well. *Creative*, technical engineering *leadership* has not been rewarded appropriately. There are two sides of technical leadership. One is technical management, which administers the day-to-day technical processes of operation, design, or calculation. The other is *creative*, professional leadership in technical matters. In this leadership is that small group of 10 per cent or so of scientists and engineers who are identified by *creative achievement*. They are the ones who can see through the technical mists which blind most of us; who thus provide the radically new concepts and methods, whether they be new forms of machines or structures, new ways of building these, or new principles and methods of predicting performance. These things are absolutely indispensable to technological progress in the same sense that the products of creative, professional leadership in management are absolutely indispensable. One whose head is a fountain of *creative* ideas is thus a technical leader, even if he cannot himself do much toward putting them into practical or material form. If he can, he is simply that much more valuable as a leader. The one quality rounds out and supplements the other. Either may predominate in equally valuable men—valuable as measured in terms of achieved results. Both functions are professional in character and are complementary in relation to each other; and therefore should be regarded more nearly on the same basis so far as reward is concerned than they have been.

However, there is a very definite, favorable trend in policy about these matters in some of the large industries, even if this is not reflected in the surveys; so there are indications that creative, technical engineering leadership is beginning to approach its proper estate.

## LOOKING TO THE FUTURE

When we orient ourselves in the direction of present trends and follow out those few clearly discernible lines from the past, they seem to lead to certain fairly definite indications. The foremost of these is that the future will have no less need than the past for leadership both in the scientific and technical fields of engineering and in management. On the contrary, the need will probably be greater; everything is getting more complex; each year it is becoming more difficult to see from one end to the other of this growing, technical-economic-social crazy-quilt with such thousands of complicated, overlapping and changing patterns. Minds trained *for leadership* will be all the more essential. Inventors must more and more have advanced scientific knowledge; the cream of invention has already been skimmed from the more obvious aspects of science, and therefore inventions will unquestionably become, in increasing measure, the product of scientists and engineers. The real leaders in technical engineering must also be more thoroughly trained in the basic sciences and in the rational applications of scientific principles to practical problems. Moreover they must learn to deal more effectively with other people, for it is a part of their job. And leadership in industrial management must likewise become broader in its outlook, more scientific in its knowledge, and more rational in its approach to general management problems. In a word, all professional leadership—not excluding law, banking, the clergy, and the rest—must broaden its outlook, perennially develop its scientific base, and improve its art; else, in the inexorable advance of complexity, the leaders will become even less able than they are now to see across the boundaries. We all have taken hold of the technological bull's tail, and it is too late to let go; instead we've got to plan pretty quickly how to guide this brainless, powerful brute toward a rational objective, or he will presently distribute us prostrate over the terrain.

Another indication is that the same forces which have moved engineers into management will continue to do so, in a somewhat modified form, in the future. In the first place it will probably be modified by the influx of a new group which has not existed during the past growth of industry, namely, college graduates who have had formal training in the fundamentals of general management, but who have had little, if any, technical engineering training. In the second place, there will be the graduates of those existing courses which, although still designated—in most cases properly so—as "engineering" are intended primarily as fundamental preparation for industrial management. Such management courses should retain those elements which engender the method and attitude that have been characteristic of engineers, and which presumably have been the keynote of their success in management.

The tremendously wide range in types of industry surely affords openings in management for men of all degrees of technical training. Even in the most technical industries there are many administrative positions which require only a very limited technical knowledge; and the higher one looks in the organization, the more this seems to be so. Hence, if the colleges do a good job, it seems practically certain that within another generation graduates of engineering-management and other less technical courses will figure heavily in industrial management.

However, there is one point to be kept in mind. There should be at least some individuals in the high levels of general management who have an understanding and appreciation of technical matters and a sympathetic interest in research. These can come most effectively from former technical leaders. The half-informed business executive who disparagingly avers that he can get all the engineers he needs at $40 per week, or who naively believes that creative processes can be put on a mass production basis, is a misfit in modern industry.

What is the future for technical engineering graduates? Are they doomed? Not at all. On the contrary, their estate should become as attractive as any, if industry and the colleges adopt wise policies. Two important phases of management indubitably will be reserved almost exclusively for them, and all other fields will be open to them just as they have been in the past, except that the competition will be more keen. One reserved field is technical administration, which has always served as a stepping stone to higher levels. The other, and altogether foremost, is the creative, professional guidance and administration of technical and scientific progress. In this latter field also will be those technical and scientific leaders who may not be capable of management in its strict sense. These fields afford broad and extensive professional opportunities for technical engineering graduates; and adding to these fields the opportunity as in the past, to enter any other phase of management, the future possibilities for such graduates can be highly promising.

## FUTURE POLICY

Educational policy cannot logically be separated from industrial policy; there are too many respects in which they are tied together. Most engineering graduates enter industry of one form or another, hence engineering colleges always have taken into account the requirements of the industrial job. When industry wanted graduates who were "practical," the colleges built workshops and tried to make their courses practical; when it changed its mind and insisted rather upon more "fundamentals," they gradually swung in this direction; and when it put large numbers of engineers into management, they worked out courses which would be preparatory to management. Thus any rational educational policy must give appropriate recognition to this interlocking of interests between the industries and colleges.

Moreover, an educational policy surely would be inadequate that did not recognize the often expressed hope that the engineer might sooner or later take an active interest in those unsolved, complex social and economic problems which his technology has largely created. What should that recognition be? Sociology, industrial history, and more economics? Undoubtedly this would be valuable to the engineer if he later took such an active interest, but those engineering graduates who have gone into business, banking, management, etc., have not done so because they have studied such subjects in college; forces of circumstance and, above all, a special type of qualification have combined to move them there. In all probability if the engineer ever takes an effective hand in the solution of such social problems, it will not be because he studied subjects relating to them as a major part of his curriculum; for if he did, he wouldn't be an engineer, by definition.

There is an unfortunate and illogical tendency to classify as engineering almost everything that is done thoughtfully. The two most distinguishing characteristics of engineers are straight thinking and an unqualified respect for facts. There seems to be a growing tendency in engineering circles to assume that these characteristics are inherently present in engineers and inherently absent in others; that other professional activities—general management, business, finance, etc.—become engineering when they are thoughtfully done; and that engineering training is the only sound educational basis for such activities. However, a statement probably much nearer the truth is that, although the definite laws and data of engineering are favorable to the development of such characteristics, nevertheless engineers develop these to a high degree simply because otherwise they cannot endure professionally. The necessity of developing fully such characteristics has been less pressing in other professions. Perhaps the latter may learn something from engineering. If so, good. But let us keep engineering as engineering, and not try to stretch its curriculum over the whole domain.

Some general observations should be stated now regarding college educational process, as the writer views it. This is venturesome, because he is not qualified as either a professional educationist or a psychologist, and therefore may violate technical terminology and perhaps more; but it seems necessary, for the purpose in hand, to state in a layman's terms the more or less distinct phases of educational process as they appear to him. There are thus five largely parallel phases, as follows:

1. The first relates to the process of acquiring factual and definitive knowledge. One learns, for instance, the factors in the "flexure" formula in mechanics; the *definition* of "marginal utility;" that Disraeli was an English statesman. It is the process of building up one's mental encyclopedia. It is essentially a memory matter.

2. The second has to do with that type of reasoning in which the student is *led*, step by step, through logical processes either by a teacher or by a text-book. His part in this particular phase of his journey through the educational forest is not to move precariously along a trail which is only blazed; instead he rides on an educational sight-seeing bus over a modern, concrete highway of which even the curves and grades are reduced to a minimum. His only responsibility is to take due note of the scenery, and of the announcer's comments as he rides along. For instance, he may thus be escorted through the *logical development* of the "flexure" formula; of the *theory* of "marginal utility," or of the vector representation of alternating currents. This process is one of civilization's necessary short-cuts to the frontier of new things. In the process one's mental muscles are developed somewhat, but not under their own power.

3. The third phase is the process of acquiring skill in manipulation. For example, one develops skill in algebraic transformations; in numerical calculation from formulas by the slide rule; in operating a machine; or in carrying out an experiment. It is a discipline in procedure.

4. The fourth phase relates to that type of reasoning in which the student himself takes the initiative. *He* establishes the trail. The objective at first may be defined for him, and perhaps its general direction and a few landmarks may be indicated; but he presses through alone. In clearing away the undergrowth, in fording or swimming the technical streams which cross his path, in retracing his steps for a new start when he encounters an impasse, he not only exercises his mental muscles in worthy activity and stretches them to the elastic limit, but also develops his sense of direction and his power of discerning helpful landmarks. Each successive trail thus established *by him* increases his pioneering powers; and presently he will be able, if it is in him, to blaze his own trail through new areas to new objectives.

5. The fifth has to do with the establishment of a natural continuity between the development of the individual at college and after college. The branches of a truly educational program will neither terminate in dead ends here and there during the college course, nor be chopped off at graduation. Instead, they will feed *primary educational stems* which will continue and expand beyond graduation as long as the individual is on the ascending slope of his professional career. However, the extension of such stems after graduation is extremely difficult unless the student has already begun to extend them under his own steam before graduation. He must develop under guidance both the *desire* and *power* to extend them. This means a competent leader as a teacher, a curriculum well balanced for the purpose, and a plan obvious to the student.

Of the foregoing five phases, probably the first three are essential in the preparation for engineering work of any character; they are sufficient for *routine* technical activity, but the last two, in addition, are absolutely essential to progress toward any highly *professional* goal. If they are omitted at college, as they largely are, the graduate is obliged to provide them somehow after graduation, or else not reach the goal. To correct this situation—to provide phases 4 and 5—is, in the writer's opinion, the foremost problem confronting pre-professional education.

Turning more specifically to the engineering management aspects of educational policy, those students who would come within the scope of our subject can be classified under four divisions according to natural qualifications and appropriate education. It still may be very difficult practically to identify these groups completely, but they exist nevertheless, and every effort should be made to learn better to identify them. They are as follows:

**Sub-Professional Group**—Those primarily qualified by nature to carry out assigned tasks, either in technical work or in routine supervision. These comprise at least one-half of all college students that come under the scope of our subject. They comprise not only those whose intellectual qualifications limit them to such activities, but also those who don't want to do anything else. There are people of high intellectual ability who shrink from responsibility of any kind, or who are misfits, or who are plain lazy. They all seem to share a common level. The educational program for this group, excepting the misfits and the lazy ones, should be that of the technical institute which recognizes primarily the first three phases.

**Professional General Management Group**—Those who have outstanding natural powers of leadership and understanding, but relatively little technical leaning. This group may be expected to fill a portion of those positions of industrial and business administration—general management—which do not require technical knowledge.

Just what their educational program should be is a question largely outside the writer's knowledge. However, they must be well educated men of reasonable culture. Hence it is safe to say that there should be at least two, possibly three, stems: a cultural, a social, and economic, and possibly a slim technical one. The experiment of training men directly for general management is an interesting one, and should be encouraged. One great danger to be guarded against, of course, is the idea in students' minds that such a course provides the "royal road" to general manager or president.

**Professional Engineering Group**—Those who have outstanding natural talents along technical lines, some of whom have, in addition, the natural qualities of human leadership. From this group we should expect the future technical leaders; to some degree, leaders in general management and possibly also a few who would become actively interested in the larger social and economic problems.

Their program at college should have three stems—one main and two auxiliary: technical, cultural, and social and economic. The first and main stem should be a rigorous and thorough technical discipline. It should recognize all five phases; it should lay more emphasis upon the interpretation of fundamental physical laws and their application to the solution of illustrative problems than upon the memorization and use of standard formulas in connection with type-form cases; it should continually consolidate the gains achieved in all branches by feeding them into the main educational stem. For instance, in the junior and senior years it should make use of the results achieved in mathematics, physics, and mechanics, not in separate problems in as many classifications, but in engineering problems involving all. Past achievement would thus be unified with respect to the main purpose.

The cultural stem necessarily must be slim. But it can and should be vital. Perhaps the most that can be expected in the brief time available is to emphasize the technique of speech and writing (phase 3) and its fundamental purpose—namely, to express an idea clearly—and to *engender the habit and desire* of purposeful reading of historical, philosophical, and other cultural literature (phase 5).

While the social and economic stem is like the cultural in two respects, nevertheless it is of relatively greater importance. It is like the latter both in that it is auxiliary in character, and that the general educational purpose is gradually to establish the habit and desire of reading and thinking in a given field. In this case, however, it is about such practically important matters as industrial history, human relations in industry, sociology and economics of engineering industry and business. Taking courses in such subjects and letting it go at that is not enough; it must all be purposeful.

**Professional Engineering-Management Group**—Those all-round, capable men who have a definite technical leaning and also the natural qualities of leadership. This group, after graduation, may be expected to pass along the industrial, three-stage separator in which the first stage comprises the lower and moderate levels of technical activity; the second, technical management; and the third general management. Each stage will take its toll of men. And again, one would hope that some of these would ultimately become interested in general social and economic problems.

Their college program should have the same three stems as the *professional engineering group*, but there should be a fundamental shift in emphasis in two of them. This group should develop and retain the engineer's attitude and his respect for quantitative facts and measurements, because that attitude and respect will always be highly useful, and because technical engineering practise presumably will constitute the entrée to management responsibilities. However, the latter, being the main objective, should be given a corresponding weight in the program. Thus the social and economic stem should receive the same relative weight as the technical stem for the professional engineering group. For the present group, the technical stem should lay relatively greater emphasis on the first two phases; the social and economic should emphasize the last two phases. Analytical and pioneering powers should be exercised heavily on the subject matter of the social and economic stem, so that this will have a vital growth after graduation. For illustration, take human relations in industry. Can you teach in undergraduate courses the professional technique of personnel management, or the art of getting along with associates? It would seem to be quite hopeless. But you can introduce the student to fundamentals, and exercise his analytical powers on actual personnel problems—all with the idea of developing a purposeful and enduring interest.

The cultural stem should presumably be the same as that for the *engineering group*.

## SUMMARY

During the development of industry, engineering and industrial management have evolved together. Certain phases of management, as the writer views it, have actually been a part of engineering; others have not. The direct administration of technical engineering activities *is* engineering in the same sense that the administration of personnel and procedure in a legal matter is law. However, we should not become confused; the further movement of engineers from such technical management to general management has not made the latter become engineering, any more than the movement of numerous lawyers also into general management has made it become law. It is still general management. Engineering and management are thus closely related, but all management is not engineering.

Looking to the past, the facts are that more than a quarter of engineering graduates have gone into general management; a quarter have remained in technical management, which is engineering; a quarter, in purely technical activity; and the rest in sales, consulting, teaching, etc. Those who have gone into general management have received the greatest financial reward; those who have remained in purely technical activity, the least.

Looking to the future, it appears that technical engineering graduates will have the same opportunity as in the past for movement into such positions, excepting that they will be in competition with graduates of courses designed as fundamental preparation for executive positions. There is a very real danger that both the prospect of a greater financial reward and the less exacting nature of these presumably more direct courses in preparation for management will cause many who are naturally qualified for such work and who will be needed for technical leadership in the next generation to turn from technical engineering courses. The problem of financial reward is one which the college cannot solve; industry must do it, not alone to give creative technical leadership its due, but, in industry's own interest, to prevent the source of technological progress from drying up.

For the purpose of defining educational policy, the students who fall within the scope of our subject can be broken down into four divisions: a *sub-professional* group, and three professional groups, namely, *engineering*, *engineering-management*, and *general management*. The educational program for the sub-professional group should be that of the technical institute. It should recognize primarily the first three phases of educational process—the acquisition of factual and definitive knowledge; the development of technique in manipulation and procedure; and the understanding of basic theory. The programs for the professional groups should recognize all five phases, and should emphasize particularly the last two—*viz.*, the exercise of analytical and pioneering powers; and the development of *primary educational stems*, and of the power and desire to extend and expand them after graduation. It is around these stems that the results of purposeful study and experience will be structurally articulated. The professional groups, it seems, should all have the same three stems: (1) cultural, (2) social and economic, and (3) technical. Merely the emphasis would be appropriately different.

The present inability completely to classify all students according to natural aptitudes should not discourage us. Such a classification is now possible to a limited degree. In any case *a* division is made; boys actually do choose to be engineers, lawyers, managers, etc., and college courses are set up to train them. A rational solution of the educational problem, it seems, can be approached only as we learn progressively to sift out types during the lower educational stages, and somehow help the individuals to find their way into activities along the lines of their natural aptitudes.

In a summary word, let us recognize the necessity of providing appropriate educational preparation for industrial management; but in our enthusiasm for this, let us not misinterpret past experience and thus fail to recognize another equal necessity; we must also provide both an appropriate educational preparation and a promising outlook for technical engineering leadership. Its contributions to technological progress surely bespeak a greater recognition than it has had. But mere justice is not the point here. It is a question whether, by a stupid perversion of emphasis now, we shall encumber the next industrial generation with the problem of a dried-up source of technical engineering leadership. Wide publicity of the new facts regarding attractive salaries in management, and the continued establishment—proper as this may be—of less exacting courses leading to management, will, it seems, inevitably discourage the more capable men from choosing technical engineering courses. The solution is not to suppress the facts or to discourage management courses, but for industry to recognize the situation, as some are beginning to do, and appropriately reward technical engineering leadership; in other words, to make such leadership a worthy and promising goal on its own score, and not merely as an entrée to general management.

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# Conductor Vibration on Transmission Lines—1

**Laboratory tests reveal some interesting characteristics of conductor vibration and its effect upon conductor life; common hardware accessories, and less-common vibration dampers, are shown to have marked effects. Mathematical analyses of the stresses in standard sizes of conductors as commonly used for electric power transmission lines check closely with these stresses as measured. Field experiments in conductor vibration will be treated in another article which will appear in a subsequent issue of ELECTRICAL ENGINEERING.**

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FAILURE of conductor strands from fatigue induced by vibration has occurred in widely separated places throughout the world. Although but a small percentage of the total mileage has been affected, a study of the nature of the phenomenon and means of combating it is warranted. Any suspended cable, irrespective of material, span length, tension, size, or character of supports will vibrate under certain conditions. This natural phenomenon always has occurred, but only in recent years has it been recognized as the cause of fatigue failures formerly attributed to crystallization.

About 1925 when the importance of conductor vibration began to be appreciated, Aluminum Company of America started an investigation both in field and laboratory. The early results were included in two Institute papers by Theodore Varney. In the first ("Notes on the Vibration of Transmission Line Conductors," A.I.E.E. TRANS., v. 45, 1926, p. 791), a theory of the cause of vibration was presented which has received general acceptance; in the second ("The Vibration of Transmission Line Conductors," A.I.E.E. TRANS., v. 47, 1928, p. 799), reinforcement by armor rods was proposed as a means of protection. Recently several papers dealing with vibration have been published, particularly abroad. This article summarizes and interprets the results of laboratory work conducted by Aluminum Company of America since the publication of Varney's papers. It is planned to treat the field work in a subsequent article.

The problem of eliminating vibration troubles involves the consideration of several factors. Determination of these factors demands a better understanding of:

1. The actual stresses occurring in the conductors under field conditions.
2. The fatigue or endurance limits of the conductor materials.
3. The effects of various types of conductor accessories.
4. Practical means for minimizing the effects of, or preventing, harmful vibration.

With these considerations in mind many laboratory tests have been carried out during the past 7 years, under conditions quite comparable to those in the field. While this work by no means is completed, so much progress has been made that the results obtained should be of great interest to transmission engineers.

In the vibration laboratory of the Aluminum Company at Massena, N. Y., large concrete piers are provided so that 13 different spans of conductors may be tested simultaneously. The nominal length of each of these spans is 120 ft. Total tensions up to 20,000 lb. can be maintained on each specimen by means of suitable levers and weights. In addition to these, 4 50-ft. spans are available for tests on single wires and small stranded conductors. A general view of 1 wing of the laboratory, Fig. 1, shows some of the longer spans on the left and the 4 short spans on the right. A more recent installation of vibration equipment is shown in Fig. 2. Tests on these spans utilize higher frequencies than those carried out on the long spans; frequencies used for single wires on the 4 shorter spans are still higher, sometimes being as high as 7,000 vibrations per min. These higher frequencies are made possible by mounting an unbalanced flywheel directly on the specimen as shown in Fig. 3. Motion caused by the rotation of this flywheel is restricted to the vertical plane only. Variable speed friction drives permit the use of constant speed motors. For such tests,

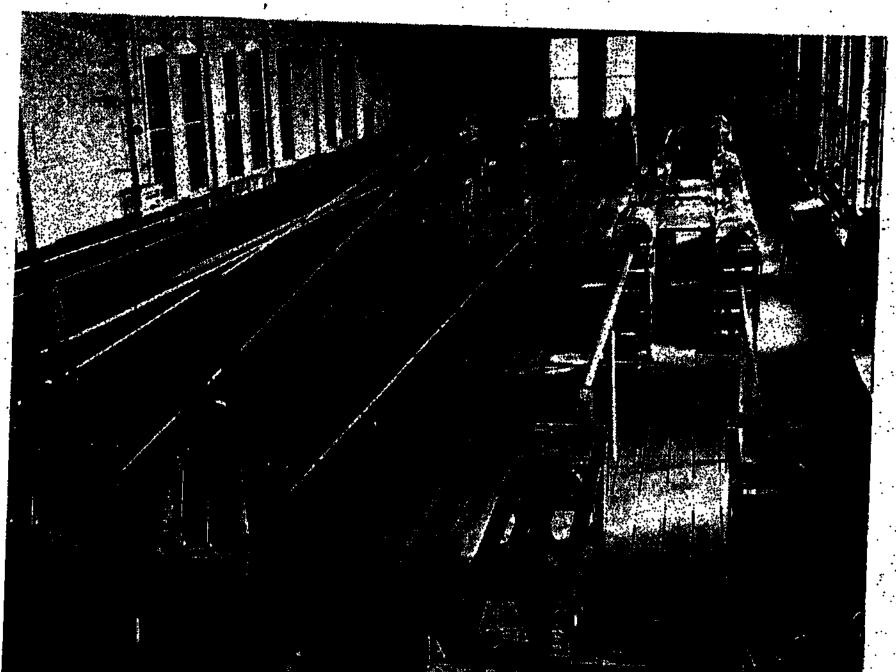

Fig. 1. One wing of the Massena, N. Y., vibration laboratory

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Essentially full text of the first portion of a paper, "Vibration of Overhead Transmission Lines" (No. 32-90), presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932.

however, it is necessary that the speed of the driving unit remain constant within extremely narrow limits. To accomplish this it was necessary to install a special inverted motor-generator set. Many of the vibration tests have been made primarily to determine the comparative life of various sizes of conductors under severe conditions. A large mass of data is available, but the summarized results in Tables I and II for 2 sizes of A.C.S.R. (aluminum cable steel reinforced) are sufficient to illustrate several interesting facts. In the case of the 795,000-cir. mil A.C.S.R. vibrated in 7 loops on a 120-ft. span, each loop having an amplitude of $1^{1}/_{8}$ in., the marked increase in number of cycles required to cause failure as the cable tension is decreased should be noted. By reducing the tension from 18,000 to 15,000 lb. the life of the cable is almost doubled for all 3 test conditions. Similar increases were observed for still lower tensions. The data in Table II for 397,500-cir. mil A.C.S.R., vibrated under somewhat different conditions, emphasize this same fact. Further consideration of the data indicates that the outer strands must be severely stressed. This is especially evident in tests made using the square faced clamps. The repeated bending imposed on these specimens irrespective of the tensions used undoubtedly was more severe than occurs in the field.

## DETERMINATION OF STRESSES

Adequate analysis of stresses in vibration conductors includes a consideration of the general phenomenon of vibration. The studies of such investigators as Varney, Relf and Ower ("The Singing of Circular and Stream Line Wires," Aeronautical Research Committee, *Report No. 825*, March 1921), and Ryle ("Conductor Vibration," *Inst. of Elec. Eng.*, Dec. 1930) certainly have helped to make possible a better understanding of this phenomenon. To determine whether or not under any given set of conditions the fatigue limit of the material in any conductor will be exceeded, it is necessary to know the location and magnitude of the maximum stresses.

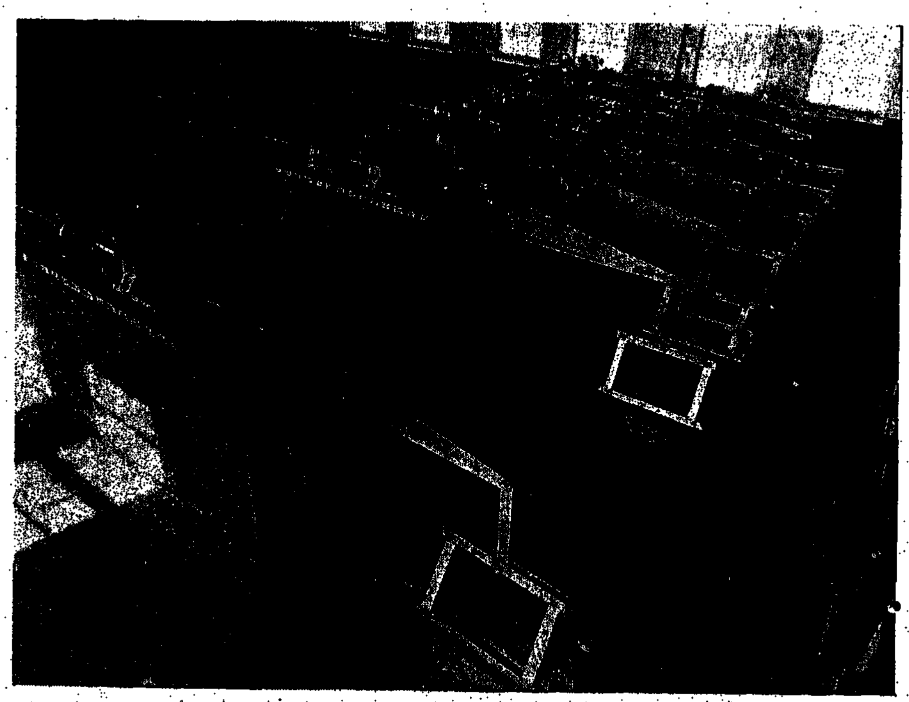


Fig. 2. Method of loading cables in tension

**Table I—Summarized Results of Vibration Tests**

795,000 cir. mils A.C.S.R. $\left(\frac{54 \text{ x } 0.1214}{7 \text{ x } 0.1214}\right)$

Span: 120 ft. No. of loops: 7 Amplitude: $1^{1}/_{8}$ in.

| Cable Tension, Lb. | Cycles for First Failure of a Strand in the Cable | | |
|---|---|---|---|
| | Square Clamp | Bell-Mouth Clamp | Bell-Mouth Clamp With Armor Rods |
| 18,000 | 433,000 | 1,148,000 | 24,000,000 |
| 15,000 | 796,000 | 2,078,000 | 40,538,000 |
| 10,000 | 1,166,000 | 6,242,000 | 95,400,000* |
| 7,000 | 9,770,000 | 16,211,000 | 110,700,000* |
| 5,000 | | 75,200,000* | 84,900,000* |

* Test still running when this article was prepared.

**Table II—Summarized Results of Vibration Tests**

397,500 cir. mils A.C.S.R. $\left(\frac{30 \text{ x } 0.1151}{7 \text{ x } 0.1151}\right)$

Span: 120 ft. No. of Loops: 14 Amplitude: $^{9}/_{16}$ in.

| Cable Tension, Lb. | Cycles for First Failure of a Strand in the Cable | | |
|---|---|---|---|
| | Square Clamp | Bell-Mouth Clamp | Bell-Mouth Clamp With Armor Rods |
| 7,000 | 3,775,000 | 11,289,000 | 49,910,000 |
| 5,000 | | 26,380,000 | 176,100,000* |
| 4,000 | 45,316,000 | 106,210,000 | 377,000,000* |

* Test still running when this article was prepared.

If stresses exceeding the fatigue limit are repeated many times, failure eventually will occur, the time depending upon the magnitude of the stresses.

The most direct method of evaluating the stresses in a cable under given conditions of vibration is by actual measurement. While at first thought this may appear impossible because of the limitations of available strain measuring apparatus, it has been found feasible by preparing and testing special large specimens, geometrically similar to those of usual size. So far 2 such specimens of 7-strand conductors have been fabricated and tested: One is a 7-strand hard drawn aluminum cable, each wire being 0.375 in. in diameter and possessing mechanical and electrical properties identical with those of standard conductors; the other is A.C.S.R. composed of 6 strands of the same wire stranded over a single steel wire. Using a span of 120 ft., these specimens have been tested with various tensions and frequencies.

It was found that these large specimens could be set in a steady state of vibration, and the position of the top and bottom of the cable at any desirable distance from the end support determined accurately by measuring with micrometer calipers the distance to suitable reference planes. The position of the cable for different test runs could be checked within a few thousandths of an inch, and from the measurements the deflection curve for the cable could be determined accurately when vibrating as well as when not. It was then comparatively easy to displace the cable under suitable static loads to the same extreme positions it assumed while vibrating. Strains measured with the cable in the deflected positions should correspond closely with those in the cable during vibration. A comparison between the measured and computed positions of the cable near the clamped end, while vibrating, is shown in Fig. 4. Cable positions resulting from static loading are so nearly identical that the differences cannot be shown in this diagram.

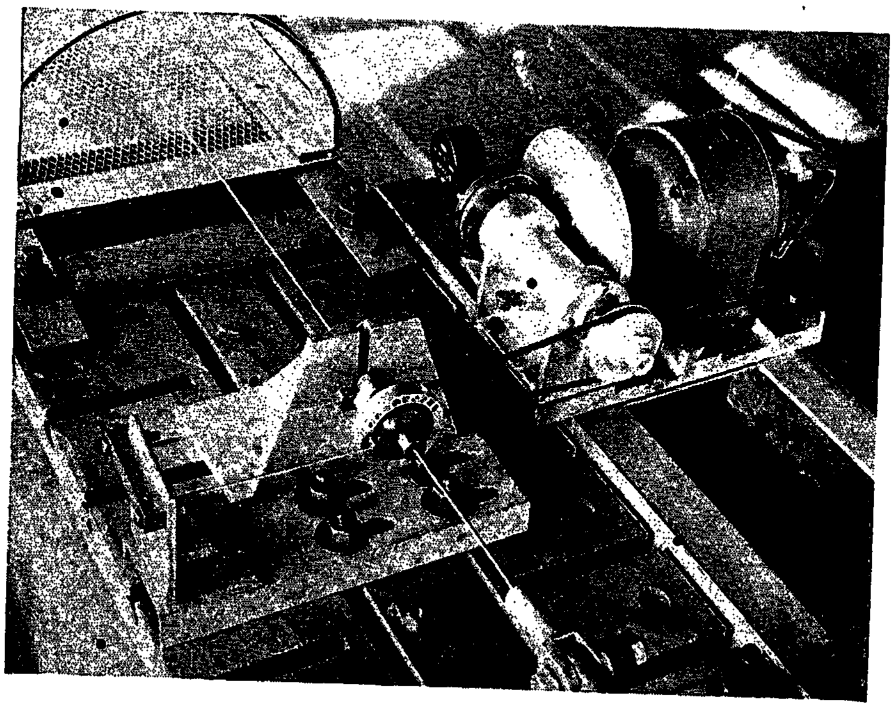


Fig. 3. Unbalanced flywheel for high frequency vibration of wires and small cables. Note variable speed friction drive

By using specimens having such large strands it was possible to attach Huggenberger tensometers, using a $^1/_2$-in. gage length, to the outside strands at various positions with respect to (1) the distance from the supports, (2) the circumferences of each strand, and (3) the circumference of the conductor as a whole. Successive applications of load together with attachment of the tensometers at various points permitted a detailed evaluation of the stresses (strains × modulus) obtaining throughout the conductor. A representative set of such data for 3 positions of the cable is plotted in Fig. 5.

## MATHEMATICAL ANALYSIS OF A VIBRATING CABLE

Formulas for the general behavior of a vibrating cable already have been given by Varney. The following mathematical analysis has been developed by R. G. Sturm of the Aluminum Research Laboratories.

The frequency at which a cable will vibrate in a loop length, $L$, is equal to

$$f = \frac{6}{L}\sqrt{\frac{Tg}{W}} \tag{1}$$

where

$f$ = frequency in cycles per sec.
$L$ = loop length or distance between node points in in.
$T$ = total tension in cable in lb.
$W$ = weight of cable in lb. per ft.
$g$ = acceleration due to gravity in ft. per sec. per sec.

Stresses from each of the following sources will be considered independently and the total stress taken as the sum:

1. Stress resulting from direct tension in the cable.
2. Bending stress resulting from the static sag of the cable.
3. Bending stress resulting from the deformation of loops during vibration.
4. Increased tensile stress caused by the increase in length of arc of the vibrating cable.

In order to facilitate following the steps in arriving at theoretical values of stress, each source of stress is considered separately.

1. Stress resulting from direct tension depends upon the ratio of steel to aluminum and to a certain degree upon the stranding of the cable. For a solid rod or for a cable in which the strands are all of the same metal this stress may be computed by simply dividing the total load by the area of cross-section, i. e.,

$$S = \frac{T}{\text{area}} \tag{2}$$

If the cable is bimetallic the stresses in the different materials and the effect of stranding may be determined as outlined by G. W. Stickley ("Stress-Strain Curves for Transmission Line Conductors," Paper No. 32-68, A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932).

2. Bending stresses resulting from the weight of the cable will be practically negligible throughout the central portion of the span but might be quite severe near the clamps. In general these stresses are neglected, but in some transmission lines they may be far from negligible. If the cable is clamped rigidly in a horizontal position at the end (which is probably a more severe condition than generally exists in actual service) the bending moment at the clamp may be expressed by the equation:

$$M_0 = w\left(\frac{L_s}{2K} - \frac{EI}{T}\right) \tag{3}$$

where

$M_0$ = bending moment at the clamp in in.-lb.
$w$ = weight of cable in lb. per in.
$L_s$ = span length of the cable in in.
$EI$ = flexural rigidity of the cable which depends upon the stranding conditions, but for a solid rod would be the modulus of elasticity times the moment of inertia of cross-section in lb.-in.$^2$
$T$ = total tension in the cable in lb.

$$K = \sqrt{\frac{T}{EI}}$$

The stress resulting from the bending moment, $M_0$, may be figured by the bending moment formula,

$$S = \frac{M_0 c E_0}{3EI} \tag{4}$$

where

$E_0$ = modulus of elasticity of the material in the outer strands in lb. per sq. in.
$EI$ = flexural rigidity of the cable in lb.-in.$^2$
$c$ = half of the outside diameter of the cable in in.

The value of $EI$ for a stranded cable cannot be determined analytically because of the interplay of the strands upon one another. The effect of the stranding is not entirely independent of the tension applied to the cable and, therefore, must be determined for the average working tensions under which the cable will be used.

In order to determine the values of $EI$ for stranded cables, load-deflection tests were made on the center section of a long cable. A span length of at least 6 times the lay of the cable was chosen in the center portion of the span. Supports were blocked up under the cable and the cable clamped to the supports after the tension had been applied. Transverse load then was applied to the midpoint of this secondary span and deflection readings taken for increments of load. Ordinary beam formulas for determining these deflections no longer hold because of the relatively large direct stress in the member. Setting up the differential equation representing equilibrium and continuity in the beam, it is found, however, that

$$\frac{d^2y}{dx^2} - \frac{T}{EI}y = \frac{M_0}{EI} - \frac{PL}{4EI} + \frac{Px}{2EI} \tag{5}$$

where

$P$ = load at the center of the intermediate span in lb.
$y$ = deflection in the direction of the load in in.
$x$ = distance from the left end of the intermediate span in in.

and other terms are as previously defined.

A solution of this equation gives not only the shape of the deflected cable but also the equation for bending moment at every point in the cable since

$$M = EI\frac{d^2y}{dx^2} \tag{6}$$

The boundary conditions that must be satisfied are that the deflection at the clamped ends be zero; the slope at the clamped

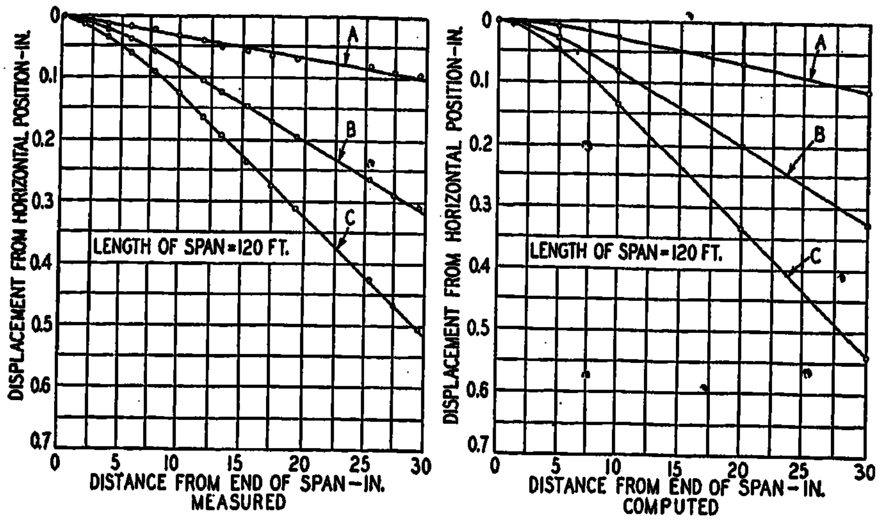
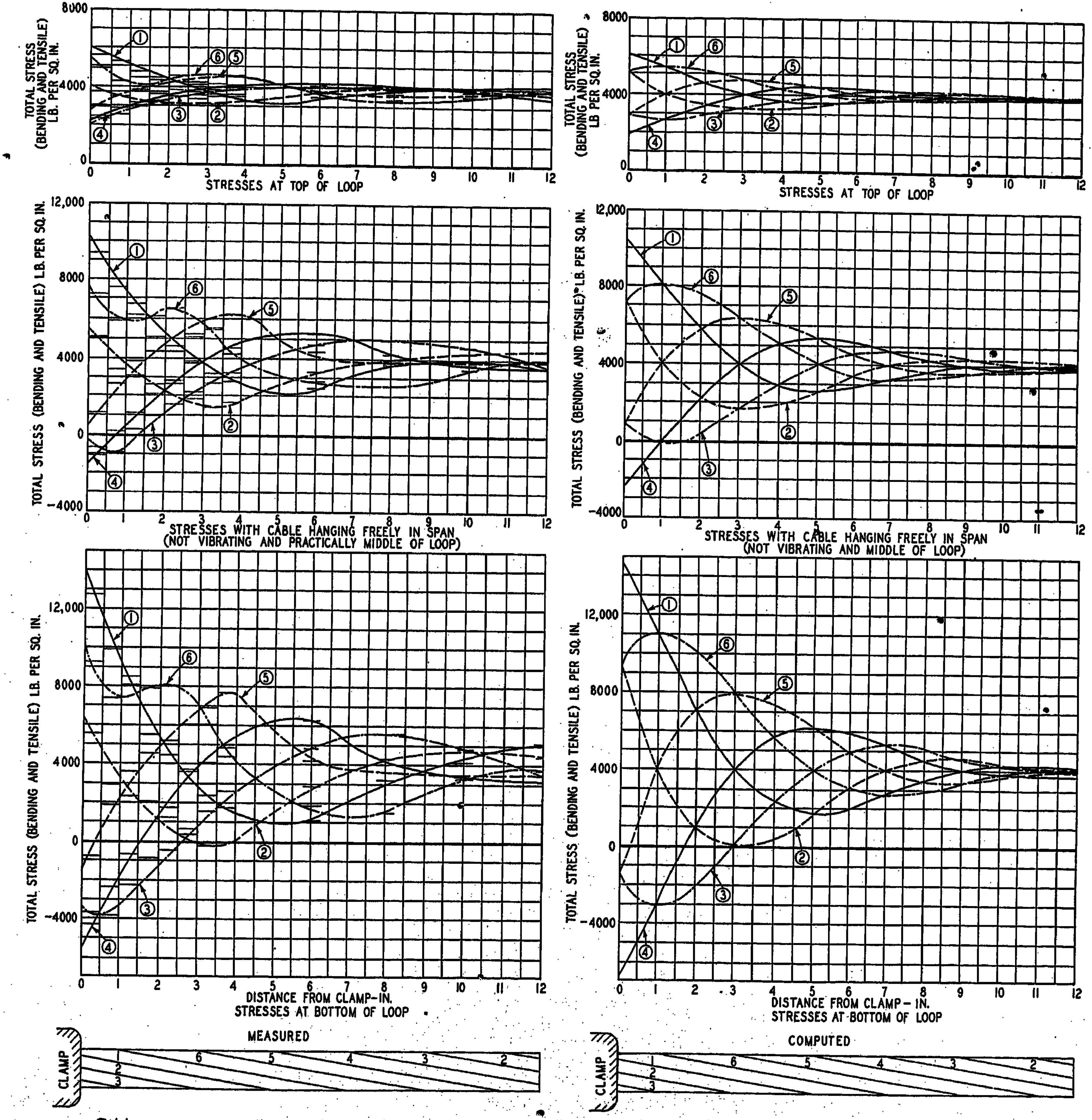


**Fig. 4. (Left) Comparison of measured and computed deflections of cable. Measured values are shown at the left; computed values, at the right**

A—Upper position when displaced either statically or by vibration (7 loops—1 1/8-in. amplitude)
B—Natural or free position of cable
C—Lower position of cable when displaced either statically or by vibrations (7 loops—1 1/8-in. amplitude)

**Fig. 5. (Below) Distribution of stress in the strands of a typical cable. Measured values are shown at the left; computed values, at the right**



Cable tension 6,000 lb.
Tensile stress in aluminum 4,000 lb. per sq. in.
Length of span 120 ft.
Length of lay of cable 12 in.
Clamp at end of span square

Stresses in the different strands of the cable at the top and at the bottom of the loop, respectively, were determined for the cable deflected statically to the same position as when it was being vibrated in 7 loops and with 1 1/8-in. amplitude end, zero; and the slope at the middle of the span, zero. The resulting solution gives

$$y \doteq \frac{P}{2KT\left(e^{\frac{-KL}{2}}+1\right)}\left[-e^{-Kx}+e^{-K\left(\frac{L}{2}-x\right)}-1+e^{\frac{-KL}{2}}\right]+\frac{PL}{4T}-\frac{Px}{2T} \tag{7}$$

Maximum deflection at the center is

$$y_m = \delta = \frac{P}{KT}\left[\frac{KL}{4}-\frac{1-e^{\frac{-KL}{2}}}{1+e^{\frac{-KL}{2}}}\right] \tag{8}$$

Knowing the load $P$ at the midspan, the tension $T$ on the cable and the deflection $\delta$ for any given span length, it is possible to determine the corresponding value of $K$ and from this the value of $EI$ for the cable. The values of $EI$ thus obtained may be tabulated for use in the stress formulas.

3. Stresses at the clamped ends or points of support caused by vibration may be computed on the basis of the static conditions that will produce a deformation of the cable identical with that occurring during vibration. It may be shown that the deflection of a span of length $L$ (the loop length) loaded with a load $P_1$, which will give a deflection equal to 0.7 times the vibration amplitude, will give the conformation desired at the clamped end. From the equation

$$\delta = \frac{P_1}{KT}\left[\frac{KL}{4}-\frac{1-e^{\frac{-KL}{2}}}{1+e^{\frac{-KL}{2}}}\right] \tag{9}$$

the value of $P_1$ which will give a deflection $\delta$, equal to 0.7 of the amplitude first is found; then the bending moment at the edge of the clamp may be computed from the formula

$$M_0 = \frac{P_1}{2K}\cdot\frac{1-e^{\frac{-KL}{2}}}{1+e^{\frac{-KL}{2}}} \tag{10}$$

where the terms are as previously defined. The stress resulting from this bending moment may be computed by means of eq. 4. It should be noted that this stress is oscillating and produces equal stress components in opposite directions on top and bottom, both being subjected to alternate tension and compression. The stresses throughout the length of cable resulting from the bending during vibration may be computed from the formula

$$S = 2\pi^2E_0\cdot\frac{c}{L}\cdot\frac{A}{L} \tag{11}$$

where $A$ = amplitude of vibration in in., and the other terms are as previously defined.

4. As the cable distorts into waves while in vibration, the length of the cable around the arcs will be greater than the length when not vibrating. The additional length thus required will result in a stretching of the cable because, in general, the clamped ends cannot yield rapidly enough. This additional length results in a unit deformation which is quite closely expressed by the formula derived by Bechtold and Folkerts ("Resistance of Cable to Transverse Vibration Especially Hollow Overhead Cable," Elecktrotech. u. Maschinenbau, July 14, 1929, p. 593).

$$\epsilon_s = \frac{8}{3}\cdot\frac{A^2}{L^2} \tag{12}$$

where $\epsilon_s$ = unit elongation of the cable, and other terms are as previously defined. The resulting stress then may be computed as

$$S = \frac{8}{3}E_0\cdot\frac{A^2}{L^2} \tag{13}$$

in which $E_0$ = modulus of the cable as a whole.

This stress is simply an increase in tension of the cable which in general is quite small but which may not be negligible in many cases.

By proper combination of all of these stresses the total stresses in the vibrating cable may be computed with a fair degree of accuracy. Stresses actually measured in a cable with those computed on the basis outlined, are shown for comparison in Fig. 5. It may be noted that stresses measured on the top part of the cable, i. e., where tensile stresses are great, are slightly lower than the theoretical stresses; whereas on the under side of the cable, where compressive stresses exist, measured stresses are somewhat greater than the computed stresses. This difference is due to the fact that the tensile stress tends to pull the strands closer together, whereas the compressive stress causes them to push out thereby tending to move the neutral axis toward the top of the cable.

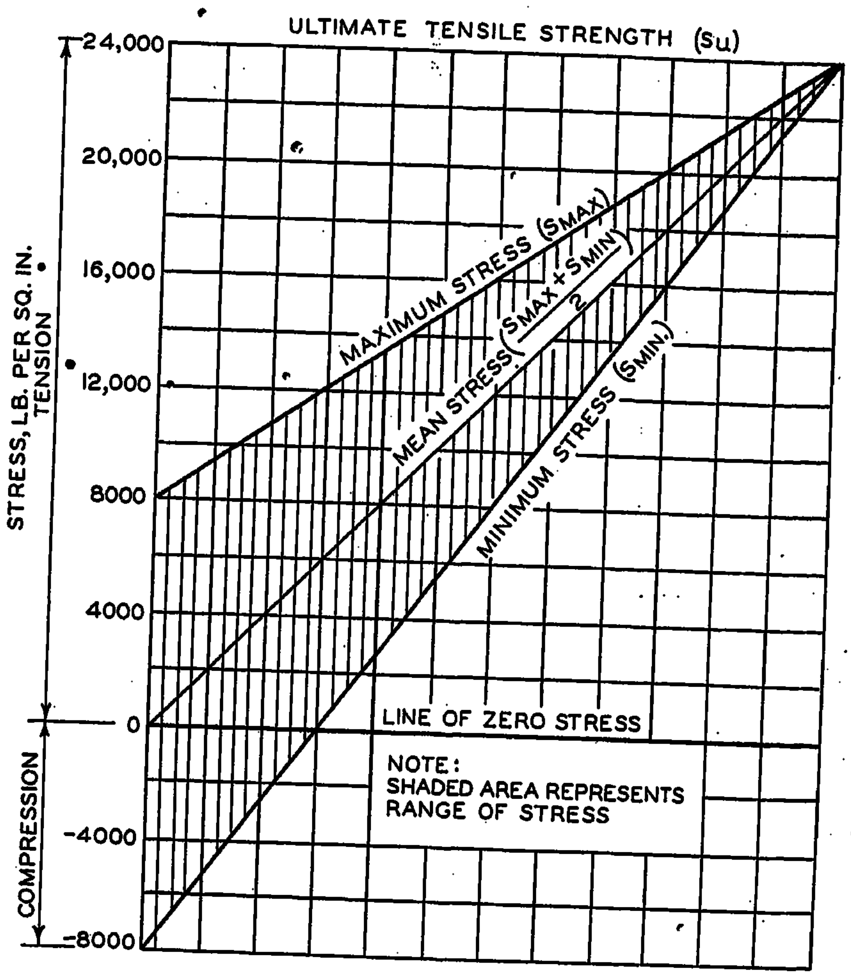


**Fig. 6. Goodman diagram showing safe mean stress and safe range of stresses for aluminum conductor**

It has been found quite feasible to measure with suitable accuracy the deflection curves and determine $EI$ values for all sizes of commercial conductors. Following the general procedure just outlined measurements of stress can be made on the smaller sizes of cable. This work is now in progress and the limited results obtained to date indicate that the theoretical analysis may be accepted with assurance.

In applying this study to transmission line problems it is important to remember that no allowance has been made for relief of stresses caused by the sympathetic motion of the cable supports. The supports used for tests were practically rigid, whereas supporting clamps and insulator ties used on actual transmission lines are far from rigid.

## FATIGUE PROPERTIES OF MATERIALS

Assuming that the limits of the stress ranges for the critical section in a cable can be determined, it is desirable to know the safe limits of the stress ranges for the materials in the cable. This information is obtained best from vibration tests of single wires under various known conditions. Such tests are essentially fatigue tests in which both the mean stress and the stress ranges may be varied widely.

Tests show that when the mean stress is zero the endurance limit based upon 500 million complete reversals is 8,000 lb. per sq. in. for hard drawn aluminum conductor metal. Using this value and the Goodman diagram which, although not checked thoroughly by experimental data, has been found to give safe values, limiting ranges of stress are obtained as shown by Fig. 6. This diagram shows that as the mean stress increases from zero to the ultimate strength of the material (24,000 lb. per sq. in.), the safe range of stress decreases from 16,000 lb. per sq. in. to zero at the ultimate strength. Tests on single wires are now in progress for the purpose of checking the Goodman diagram both for hard drawn aluminum and for steel; but because of practical difficulties in carrying out the tests, results are being obtained rather slowly.

## EFFECTS OF CONDUCTOR ACCESSORIES

Many tests have been made for the purpose of determining the effects of various types of fittings on the vibration or fatigue life of electrical conductors. Space limitations, however, permit the inclusion of only a few of the results in this article. Effects of bell-mouth clamps in increasing the life of vibrating cable are well illustrated in Tables I and II where the number of cycles for failure is shown for cable with square clamps and with bell-mouth clamps. It may be noted that the life of the cable has been practically doubled in every case. This is explained by the fact that the bell-mouth clamp prevents the severe concentration of stress that occurs in the square clamp. If armor rods are used with bell-mouth clamps the life of the cable is increased many times, as illustrated also in Tables I and II. While these tests have not been completed they have run long enough to demonstrate the effectiveness of armor rods as a means of overcoming vibration troubles.

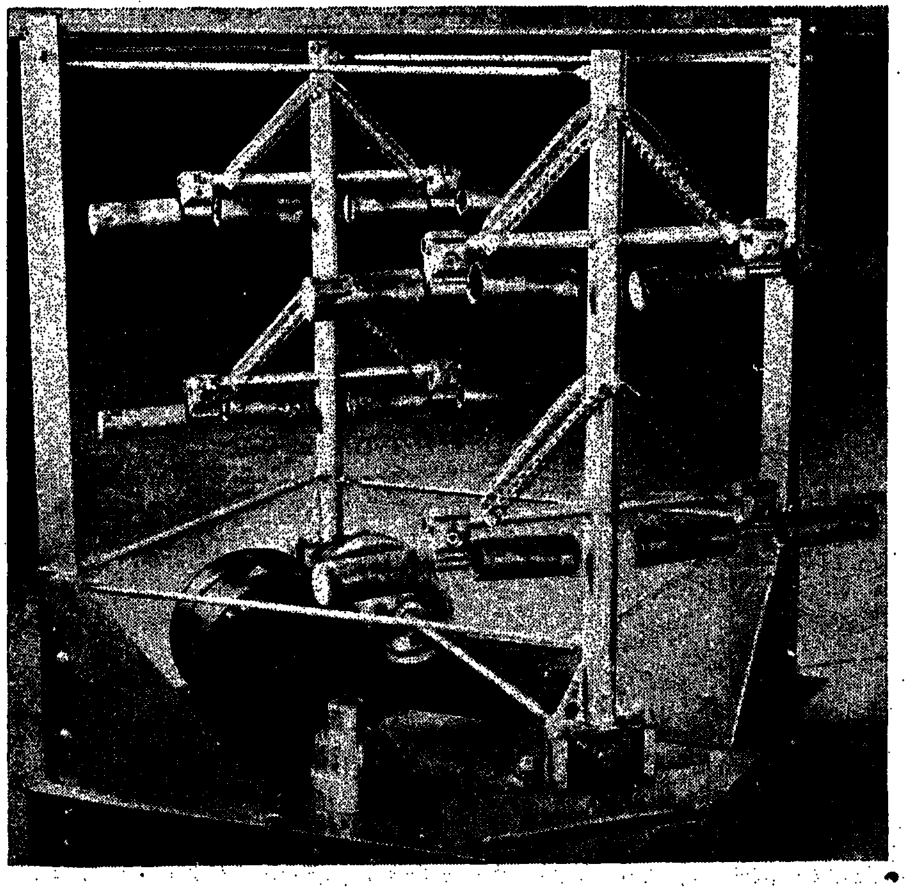


**Fig. 7. Vibration damper fatigue testing machine**

Note that the vibrating members are driven through 2 eccentrics, one of which can be seen at the lower right

It is possible by means of dampers to eliminate practically all the vibration in a cable. Laboratory work on vibration dampers has included extensive tests to determine the relative life of various dampers of the Stockbridge type using the special fatigue testing machine shown in Fig. 7. The machine can be operated at various speeds from about 600 to 1020 r.p.m. using any amplitude from zero to $1/2$ inch. Tests with this machine permit the selection of proper cable for supporting the weights and assist in refinements of design.

Another special testing machine was built for measuring the efficiency of various types and sizes of vibration dampers. This was to be done by measuring the rate of retardation of a flywheel after it and the attached damper (the damper being driven through an eccentric) were brought to a definite high speed and then disconnected from the driving motor. So far the test data have not been satisfactory for determining the efficiency of dampers, but have given valuable information relative to critical frequencies of dampers.

Dampers of the Stockbridge type (Fig. 7) have 2 critical or natural frequencies which are dependent upon the material, size, length, and stranding of the damper cable as well as upon the size and shape of the weights, and the method of attaching them to the damper cable. Computed frequencies for these devices have been found to agree with observed frequencies within the limits of experimental error. The amplitude of oscillation of the damper weights for any given forced vibration of the center clip depends upon the frequency of the forced vibration and the damping characteristics of the damper cable. With the damping characteristics of the damper cable known this amplitude may be computed and from that the energy absorbed per cycle or per second may be determined. This value together with the forces developed by the vibrating weights will give criteria for selecting the most suitable damper for any given conditions. Space limitations do not permit giving the mathematical analysis in this article.

## CONCLUSIONS

The following conclusions summarize the principal findings of the laboratory investigation treated in this article:

1. Satisfactory methods have been developed for measuring actual stresses in vibrating conductors under conditions closely simulating field conditions.
2. A mathematical analysis of the stresses in a stranded conductor under vibration is given which checks closely with measured values.
3. Tests indicate that safe limits for stress ranges of conductor materials can be determined satisfactorily.
4. Certain types of hardware accessories have marked effects upon the life of vibrating conductors.

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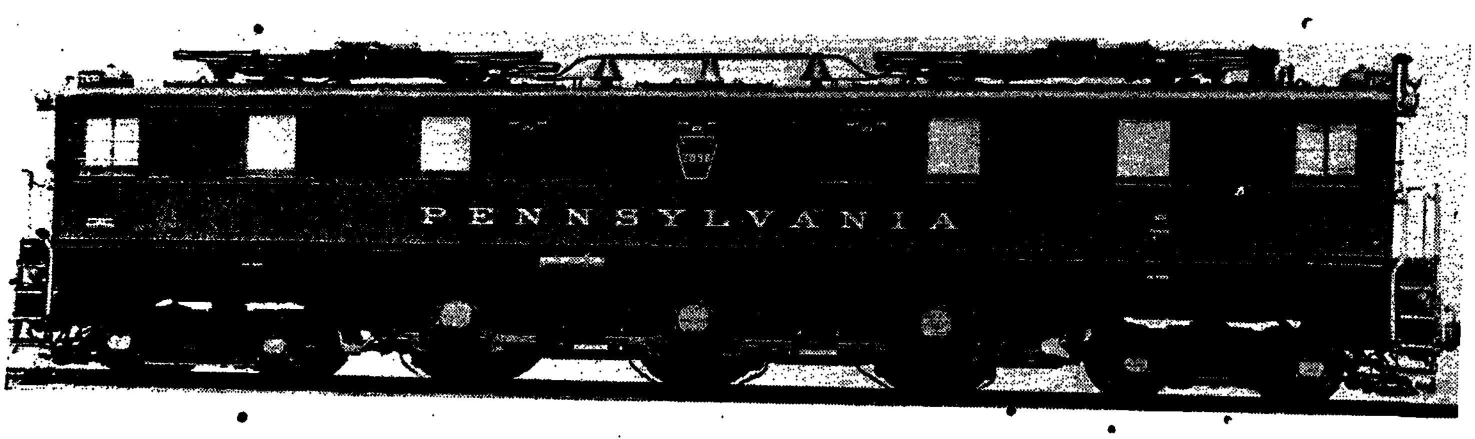
Editor's Note.—The last portion of the paper "Vibration of Overhead Transmission Lines," which deals with *field tests* on actual transmission lines, will be covered in a later article to appear in a subsequent issue of ELECTRICAL ENGINEERING.



**Heavy duty type P5 electric passenger locomotive for service on the Pennsylvania Railroad's New York-Washington line which now is being electrified**

# Electric Locomotives for the Pennsylvania

**High sustained available and controllable continuous output is considered one of the outstanding characteristics of locomotives recently designed for the Pennsylvania Railroad. This high output has been made possible by the use of motors of improved design together with transformers having suitably selected taps. Important features of these locomotives are treated in this article.**

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HIGH sustained output, interchangeability of principal parts, accessibility of parts for inspection and repair, and the unit type of construction are some of the outstanding features of electric locomotives recently designed for the Pennsylvania Railroad for use on its New York-Washington line now being electrified. Recent advances in the design of single phase a-c. commutating motors have made it possible to mount the motors between the driving wheels, resulting in a simpler, lighter, and less expensive a-c. locomotive than had been used previously on this road. Three classes of locomotives have been designed to meet varying operating needs.

In 1915 at the time the single phase a-c. system was constructed on the main line between Paoli and Broad Street, Philadelphia, it became evident that the type or types of single-phase electric locomotives best suited for general use on the Pennsylvania system would have to be determined. Electric locomotives previously developed for this railroad were designed primarily for operation in the New York terminal area. The resulting engineering studies led in 1924 to the adoption of an electric locomotive known as the L5 type, designed primarily as a general utility locomotive for the railroad as a whole. This locomotive was so arranged that by a modification of gear ratio it could be used in either passenger or freight service; and by modification of the control, it could be used on either alternating or direct current.

After extensive tests, several of the L5 locomotives were built and placed in service in the New York electrified territory. They were designed with single phase commutating motors and control equipment suitable for operation on direct current. At the same time another was equipped for operation on alternating current and placed in service in Philadelphia.

Advances in the design of single phase motors since the adoption of the L5 locomotive have made possible the development of a simpler, lighter, and less expensive a-c. locomotive. These many improvements have been incorporated in locomotives recently designed for use on the Pennsylvania between New York and Washington. In Pennsylvania Railroad nomenclature the electric locomotives to be used in this service are designated as follows: Class P5, heavy duty passenger service; Class O1, light duty passenger service; Class L6, freight service; and Class B1, switching service.

Class B1 switcher developed some years ago has been built in quantities. It is giving satisfactory performance in both a-c. operation on the Long Island and Pennsylvania railroads, and in d-c. operation on the Pennsylvania Railroad. With slight modifications this locomotive will continue to be used for extensions in switching service.

The P5, O1, and L6 locomotives are those recently designed. This article is devoted chiefly to a description of the principal features of the P5 locomotive. The more important questions affecting the design of all 3 of the locomotives are brought out, however, and by reference to the other 2 classes the relationship between the 3 is shown. Before proceeding with the actual design of the P5 locomotive, decisions on several important questions had to be made; these are as follows:

1. Weight on drivers.

After study and review of steam locomotive practise, it was decided to aim at a weight of 75,000 lb. per pair of drivers and a total locomotive weight of 375,000 lb. Consideration was given to the mechanical structure of the locomotive, the speed at which it was to operate, and to the structures and physical characteristics of the railroad over which the locomotive would be used.

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Written especially for ELECTRICAL ENGINEERING; based upon an oral presentation before the transportation group of the A.I.E.E. New York Section. *Not published in pamphlet form.*

### 2. Selection of electrical equipment.

Single phase commutating type motors were selected for driving the locomotive. In selecting these as well as the other electrical equipment, consideration was given to the best method of taking full advantage of the permissible weight on drivers, both in regard to horsepower and tractive effort, and to secure a proper balance between these factors and the capacity of the electrical equipment.

### 3. Horsepower and tractive effort.

In deciding upon these features, consideration was given to the horsepower and tractive effort of a steam locomotive that was handling through passenger trains successfully; it was felt that if an electric locomotive could be built with the same or better horsepower and tractive effort than that of this particular steam locomotive, the resulting electric locomotive would provide a satisfactory unit for handling through passenger trains.

### 4. Maximum speed.

To provide operating tolerances over present speed, and at the same time permit increased operating speeds in the future should they prove justifiable, a maximum operating speed of 90 miles per hr. was selected.

### 5. Adhesion factors.

Conservative design required the use of an adhesion factor of 25 per cent of the weight on the drivers. Experience with electric locomotives in the past indicated that this adhesion factor could be reached without trouble under almost any normal operating conditions.

In the earlier Pennsylvania locomotives of both a-c. and d-c. types, for various reasons jack shafts and side rods had been used as the means of transmitting the motor output to the driving wheels. In d-c. locomotives this was done to secure a smooth riding vehicle as well as to concentrate the driving power in a small number of large motors. In the a-c. locomotive, similar construction was used to permit the use of a minimum number of large motors, since, when these locomotives were designed it was not possible to place between the driving wheels sufficient motor capacity to handle the tractive efforts made available by the permissible weights on drivers. Developments in single phase motors, however, now permit the installation between the driving wheels of sufficient motor capacity to handle effectively the maximum weight per pair of drivers; jack shafts and side rods thus are no longer necessary, and it is possible now to design a maximum driving unit of sufficient capacity to develop the tractive effort available with the allowable weight per driving axle.

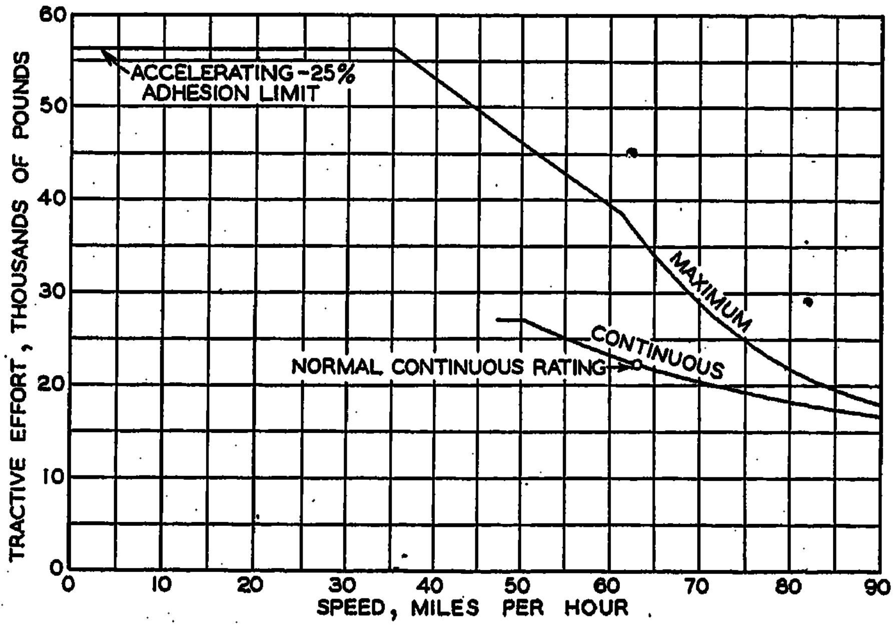
## IMPROVEMENTS IN A-C. LOCOMOTIVE MOTORS

Among developments that have made possible the increase in motor capacity referred to, may be mentioned an increase in permissible peripheral speed of both armature conductors and commutator. This increase in safe peripheral speed resulted from improvements in the mechanical design of both armature and commutator, the use of roller bearings for the armature, and improved mechanical design of gears and pinions. Another development that has contributed to the increase in motor capacity is an increase in the efficiency of forced ventilation, which has followed upon a detailed study of air distribution through the various air passages in the motor windings.

With the selection of this improved driving unit as a base, it has been possible to design locomotives of different classes for freight and passenger service, each with a suitable multiple of these driving units assembled in combination with appropriate idle trucks. Thus in the P5 locomotive, a motor unit consisting of 2 armatures and stators in a single frame was selected as the motive power for a pair of drivers, the motors driving the wheels through an adaptation of the well-known quill drive. In the O1 locomotive, identical units are used with fewer drivers. In the L6 locomotive, single motors mounted in a frame suitable for axle mounting drive the wheels by means of conventional gear reduction arrangements.

As the design of the P5 locomotive progressed it was found that 3 pairs of drivers, each pair equipped with the motor unit just described, with a 4-wheel truck at either end of the locomotive, provided somewhat greater capacity than the present through steam passenger locomotive known as the "Pacific" type. It was found also that an assembly of 2 sets of twin motors with 2 pairs of drivers and a 4-wheel truck at either end, classification O1, provided a locomotive of somewhat greater capacity than the through steam passenger locomotive known as the "Atlantic" type. An assembly of 4 pairs of drivers of approximately 60,000 lb. per pair having a single armature driving each pair through gears and pinions, with a 2-wheel truck at either end of the locomotive, provided a capacity somewhat greater than that of the "Mikado" steam locomotives used in freight service on the Pennsylvania system.

In addition to the foregoing, the designs selected permitted great flexibility of motive power: In an O1 locomotive, 2,500 hp. is available with 2 pairs of drivers; in the P5 locomotive, 3,750 hp. is available with 3 pairs of drivers; in 2 O1 locomotives, 5,000 hp. is available with 4 pairs of drivers; in a combination of an O1 and a P5 locomotive, 6,250 hp. is available; and in 2 P5 locomotives, 7,500 hp. Thus it is possible to increase locomotive capacity in steps of 1 pair of drivers, or 1,250 hp., and to select the proper unit for almost any weight or size of passenger train now used on this railroad or likely to be used in the near future.

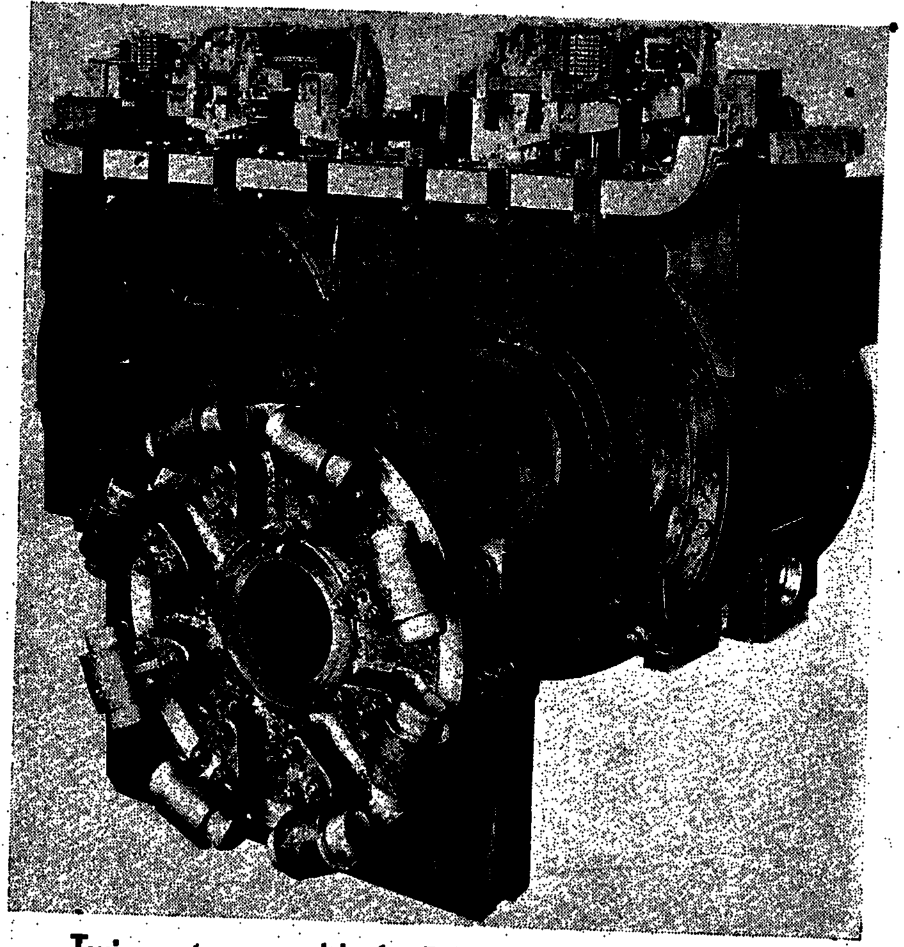


**Speed-tractive effort characteristics of the P5 electric locomotive**

While the freight locomotive's capacity cannot be increased in such steps, a careful study of freight service on the Pennsylvania has indicated that the unit selected is the best all-around one for handling freight trains on this system and that the steps in which the capacity can be increased are sufficiently flexible.

## Unit Construction Used

Experience with construction and maintenance has indicated that in any class of electric locomotive, any part should be readily removable and replaceable, and that in so far as possible, all parts should be interchangeable between individual locomotives of the same class. The desirability of still further applying this principle between different classes of locomotives is evident. With the cooperation of the manufacturers, this has been accomplished in the P5 locomotive. Any unit or part, armature, motor, brushholder, transformer, or control unit, will fit and perform properly in any locomotive assembly regardless of the manufacture of other parts in that assembly. This principle has been developed further in the locomotive assemblies in that each complete assembly consists of 3 units, a chassis, an apparatus deck, and a cab.



Twin motor assembly for P5 locomotive, pinion end, showing quill drive

*Chassis.* The chassis unit consists of the drivers, trucks, main frame, spring rigging, brake rigging, motors, flexible drives, main transformer, and train heating boiler, together with the necessary water and oil storage reservoirs, and air, oil, and water piping. Foundation for the chassis unit is a single steel casting into which are cast the oil and water reservoirs of the oil-fired steam boiler, as well as reservoirs for compressed air for the brake and control systems. At each end of this steel casting is a 4-wheel engine truck consisting of a single cast steel frame, a steel bolster casting, and the necessary spring and brake rigging.

All driving wheels, truck wheels, and motor armatures are mounted in anti-friction bearings. This type of bearing has been used extensively on this railroad for passenger car journals and for traction motor bearings; it is anticipated that by extending the use of these bearings to the driving wheel journals, truck wheel journals, and motor armatures, bearing trouble will be practically eliminated and locomotive maintenance expense materially decreased.

*Apparatus Deck.* This unit contains the main control groups, air compressor, miscellaneous apparatus, main wiring, and most of the control wiring. Foundation for this unit is a structural aluminum framework upon which the electrical equipment is assembled and wired. The assembly then is mounted as a unit directly on the chassis.

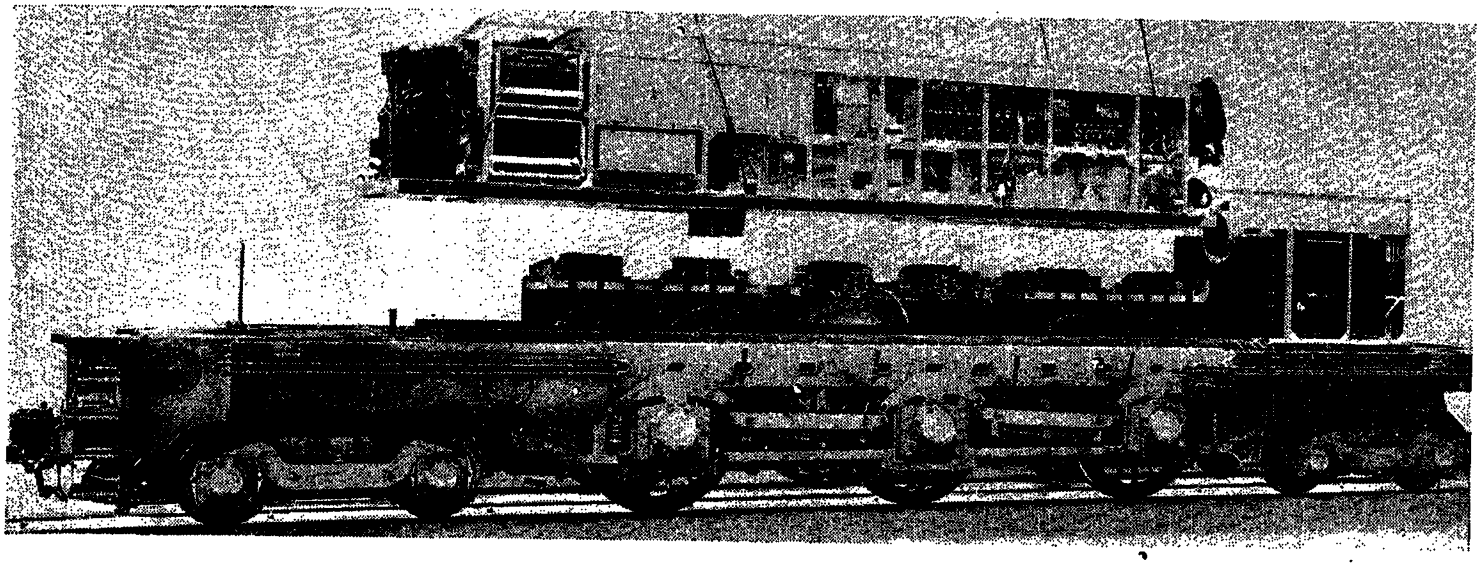
*Cab.* This unit forms a weatherproof housing for the locomotive crew and apparatus. The foundation is an aluminum structure divided into 3 compartments, a booth for the locomotive enginemen at either end, and a central compartment covering the apparatus deck. This unit houses also the heating boiler, main transformer, master controllers, the engineer's brake valves, some of the control wiring, and other miscellaneous accessories, and supports the pantographs, bell, and whistle. Louvers in the sides of the cab admit ventilating air to the motor and transformer blowers. The entire cab may be assembled as a unit, wired, and equipped with apparatus, then mounted directly on the chassis and over the apparatus deck.

Each of these 3 units of a locomotive may be assembled independently of the other, then assembled together into a complete locomotive. Parts such as a pair of drivers with motors and driving mechanism, a truck, or a control unit, may be removed and replaced with a minimum of disturbance to the rest of the locomotive.

Class O1 locomotive is in all respects similar to the Class P5 except that it has 2 driving axles instead of 3 and consequently is of smaller capacity. Equipment in the 2 locomotives is similar in every respect except that the transformer in the O1 is of smaller capacity.

Class L6 freight locomotive has 4 driving units with a 2-wheel truck at either end. Each driving unit carries but 1 motor armature with its frame, each motor being axle-borne, much in the manner used for years on trolley cars. The single motors of the L6 locomotives, however, are identical except for the frame, end housings, and pinion end bearings, with the motors of the twin units used in the passenger locomotives. In the L6 locomotive the cab and apparatus deck is of steel, as weight restrictions do not necessitate the use of aluminum.

Thus it may be seen that the P5 has 6 motor armatures, the O1, 4, and the L6, 4 motor armatures. All of these motor armatures are alike; also all twin frames are alike, as are all single frames. These motors have been rated nominally at a continuous output of 625 hp. per armature at the locomotive



Apparatus deck completely equipped being lowered upon the chassis of a P5 electric locomotive. Note unit construction. After the apparatus deck is secured to the chassis, the cab unit is added to complete the locomotive

driver rims; this gives a nominal continuous rating for the 3 classes of locomotives as shown in the accompanying tabulation.

**Ratings of New Locomotives for Pennsylvania Railroad**

| Class | Hp. | Speed in Mi. per Hr. | Tractive Effort in Lb. |
|---|---|---|---|
| P5* | 3,750 | 63.0 | 22,300 |
| O1 | 2,500 | 63.0 | 14,900 |
| L6† | 2,500 | 37.8 | 24,800 |

* Geared for a maximum speed of 90 mi. per hr.
† Geared for a maximum speed of 54 mi. per hr.

With the foregoing general description of the locomotives in mind, it may be interesting to dwell upon some of the more important details.

### PRINCIPAL PARTS INTERCHANGEABLE

Interchangeability of parts has been referred to previously in this article, but the extent to which this interchangeability has been effected has not been treated in detail. It may be said that in the 3 classes of locomotives, the interchangeability of electrical parts is practically complete. The unit switches, master controllers, air compressors and motors, pantographs, blowers for motor ventilation, and relay systems, are identical. The preventive coils and transformers are identical on O1 and L6 locomotives, but are larger on the P5 locomotive because of the greater capacity required.

Although the assembled motors on the O1 and P5 locomotives are of the twin-armature frame-supported type and those on the L6 locomotives are of the conventional single-armature axle-supported type, the individual parts of the motors, including armatures and stators, are identical except that a larger pinion bearing is used in the axle supported motor to take care of the higher duty required by the freight gearing. The same stators may be pressed into or out of either type of frame.

Mechanical parts of the O1 and P5 locomotives are interchangeable to a large extent; driving wheel assemblies including bearings are the same as are the truck assemblies; also many parts of the spring and equalizing rigging and of the brake rigging are identical. Furthermore, many of the parts used to make up the apparatus decks and cab structures are the same.

### ACCESSIBILITY AIDS INSPECTION AND REPAIR

Accessibility of apparatus for inspection and repair also has been mentioned. This was the subject of continual study during progress of design, and every effort was made to insure that each piece of apparatus is not only readily accessible for inspection but also readily removable for repair. Thus a locomotive may have a defective piece of apparatus replaced and be returned to service in the minimum time. For this purpose hatches are provided in the cab roofs of all 3 classes of locomotives. Through these hatches any piece of apparatus inside the cab may be removed readily for repair or replacement.

A complete driving wheel assembly, including the motors, may be dropped from the frame in the repair shop and replaced in a relatively short time, thus making all electrical parts of the locomotive readily accessible and renewable either from above or below. In addition to this, each piece of apparatus inside the cab may be inspected readily from the interior; commutators and brushholders of the main motors may be inspected equally readily from the inspection pit.

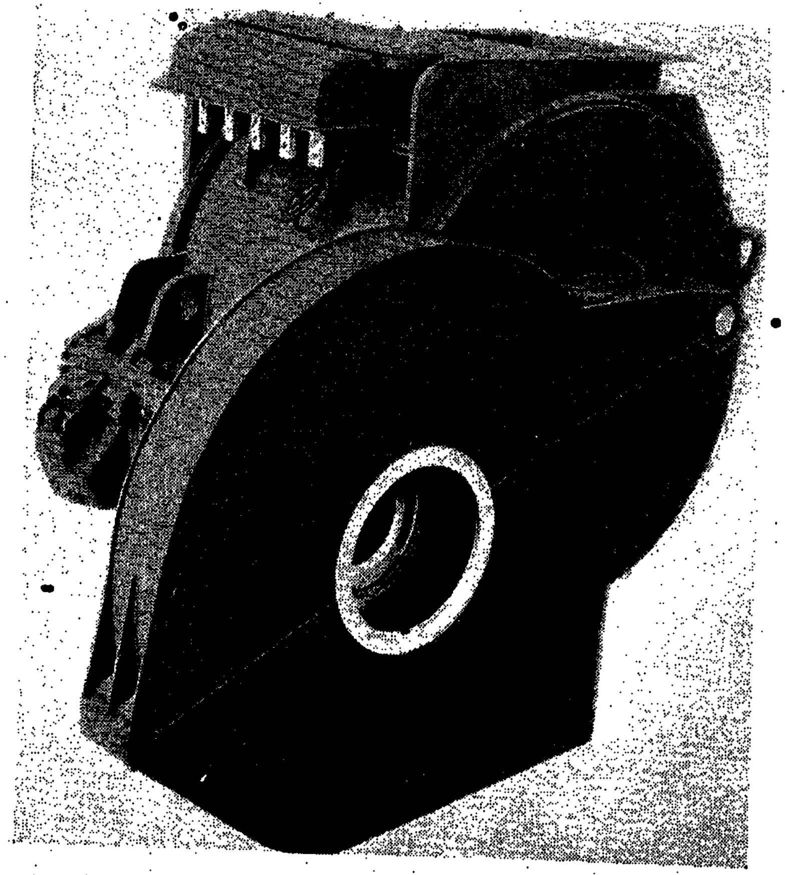
Handling the large quantity of ventilating air necessary for cooling the motors and transformers was made the subject of detailed study. In the final design louvers are provided in the sides of the cabs that may be opened or closed, depending upon weather conditions. These louvers are so designed and constructed that screening devices may be applied should further operating experience indicate that such devices are necessary.

### TYPE OF DRIVE USED

The type of drive to be used between the pinion driven gear of the armature and the driving wheel has been the subject of much detailed study and analysis; several types of drives have been built and placed in service and on test. These tests still are proceeding, however, and final decision on this question will follow at a later date. The first 90 passenger locomotives built will be equipped with the cup drive shown in one of the accompanying illustrations; so far this drive has given excellent results in service. In the freight locomotives, the conventional arrangement of pinion and flexible gear used largely in multiple unit car construction and in previous electric locomotives has been adapted to the tractive efforts and speeds of the freight locomotive.

### ELECTRICAL PROTECTION

For some years it has been the practise of the Pennsylvania Railroad to omit the use of a current rupturing device between the pantograph on an electric locomotive and the primary of the main transformer, and to substitute in its place a device known as a pantograph lowering relay. This relay is connected so as to use the substation circuit breakers to open high voltage short circuits, grounds, or overloads on the locomotive. In the P5, L6, and O1 locomotives this device has been supplemented by an automatic grounding device. Should a transformer short circuit or overload condition develop, this device will function automatically to ground the pantograph, thus opening the substation circuit breakers, after which the pantograph is lowered and locked automatically by the lowering relay.



Axle hung motor for L6 freight locomotive, showing gear case

Protection against motor overload is provided by relay devices, thus permitting the utilization of the maximum tractive effort made available by driving wheel adhesion, at the same time affording protection for the motors should this adhesion exceed normal values due to the application of sand or mishandling of the equipment. This relay protection also is interlinked with anti-wheelslip protection which insures driving wheel slippage being brought to the engineman's attention should he otherwise not detect it.

While it would be possible to enter into considerably more detail in regard to the various features of the design and equipment of these locomotives, such detailed treatment obviously would be beyond the intended scope of this article.

# Wire Communication Aids Air Transportation

**Through government aid, great progress has been made during recent years in reducing the hazards of bad weather to air transportation. Practically continuous reporting of meteorological information and weather forecasting along the principal airways is carried on with the aid of extensive teletypewriter network.**

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RAPID DEVELOPMENT of air transportation in this country has continued through the past few years so that today established routes connect nearly all important cities. Route mileage of airways in the United States as shown in Fig. 1 totals over 30,000 miles. Regularly scheduled transport service is given on practically all of these routes; in addition, the routes are used to a considerable extent by military and private planes.

Statistics relating to service of air transport companies seem particularly significant: The United States Department of Commerce reported approximately 42,800,000 miles flown in passenger, mail, and express service on domestic scheduled lines in 1931, an increase of 35 per cent over the preceding year and more than a fourfold increase since 1928. In the same 3-year period passengers carried increased ninefold, reaching a total of about 470,000 in 1931. Along with this growth, safety has been increased as is indicated by the respective 1928 and 1931 reports of 250,000 and 750,000 miles flown per accident. Reasonably regularity of schedules on air transport lines also has been maintained, the ratio of miles actually flown to scheduled miles last year being of the order of 92 per cent.

Communication facilities have been an important contributing factor to all this development and improvement. It was recognized early that fast and reliable communication would be needed in connection with any extensive development of air transportation. Communication with planes in flight was an obvious requirement; this could be provided only by radio. For land service, however, experience has indicated that wire facilities best meet the general requirements. This article de-

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Based upon "Wire Communication Aids to Air Transportation" (No. 32-82) presented at the A.I.E.E. Summer convention, Cleveland, Ohio, June 20-24, 1932.

scribes the wire communication facilities in general use today, both by the government and by transport companies, as aids to air transportation.

Principal airways have been established largely through federal aid. In addition to marking and lighting airways the airways division of the United States Department of Commerce had provided up to April 1, 1932, 67 radiotelephone stations at approximately 200-mile intervals (see Fig. 1) to be used for broadcasting weather reports and similar information to planes in flight and for transmitting directive radio beacon signals for enabling planes to keep on the course. In conjunction with these services the airways division had contracted for 24-hour teletypewriter service along 13,000 miles of main airways connecting some 250 stations, principally for the purpose of transmitting weather reports and to assist in dispatching the planes. All of these facilities have been made available without cost to aircraft operating companies and others using the airways.

In addition to the communication service contracted for by the government, approximately 5,000 miles of teletypewriter circuit are used daily in furnishing private wire communication service to several transport companies for transmitting information pertaining to the operation of their own lines. Routes on which these facilities are furnished to the government and transport companies are indicated by heavy lines in Fig. 1.

When the first air mail service was established, radiotelegraph was introduced as a means of point-to-point communication along the New York-Chicago-San Francisco airway route. At each radio station meteorological data were collected from surrounding points by means of long distance telephone and telegraph; these data were exchanged periodically through the day with the other stations over the radiotelegraph. With a rapid expansion in air transport service foreseen it was apparent that a large increase in communication facilities would be needed. There was the definite requirement for radiotelephone communication with planes which would need several radio channels allotted to this service. Considering these factors and the geographic and other conditions, it seemed that regular point-to-point service served by radiotelegraph could be provided more satisfactorily in another way.

Arrangements were made in 1928 for teletypewriter communication at several points connecting radio stations with their local weather bureau offices in order to expedite the delivery of weather reports and other traffic handled by radiotelegraph. Shortly afterward, a teletypewriter system was installed on the New York-Cleveland route connecting the Department of Commerce and weather bureau stations at Hadley Field, Shelton, N. J., and Cleveland, Ohio, and several intermediate points. This type of service seemed ideally fitted for use in weather reporting and plane dispatching and has been extended not only to replace the service previously furnished by radiotelegraph, but also to provide for communication requirements of other routes.

Teletypewriter service offers the advantages of simultaneous communication with any desired num-

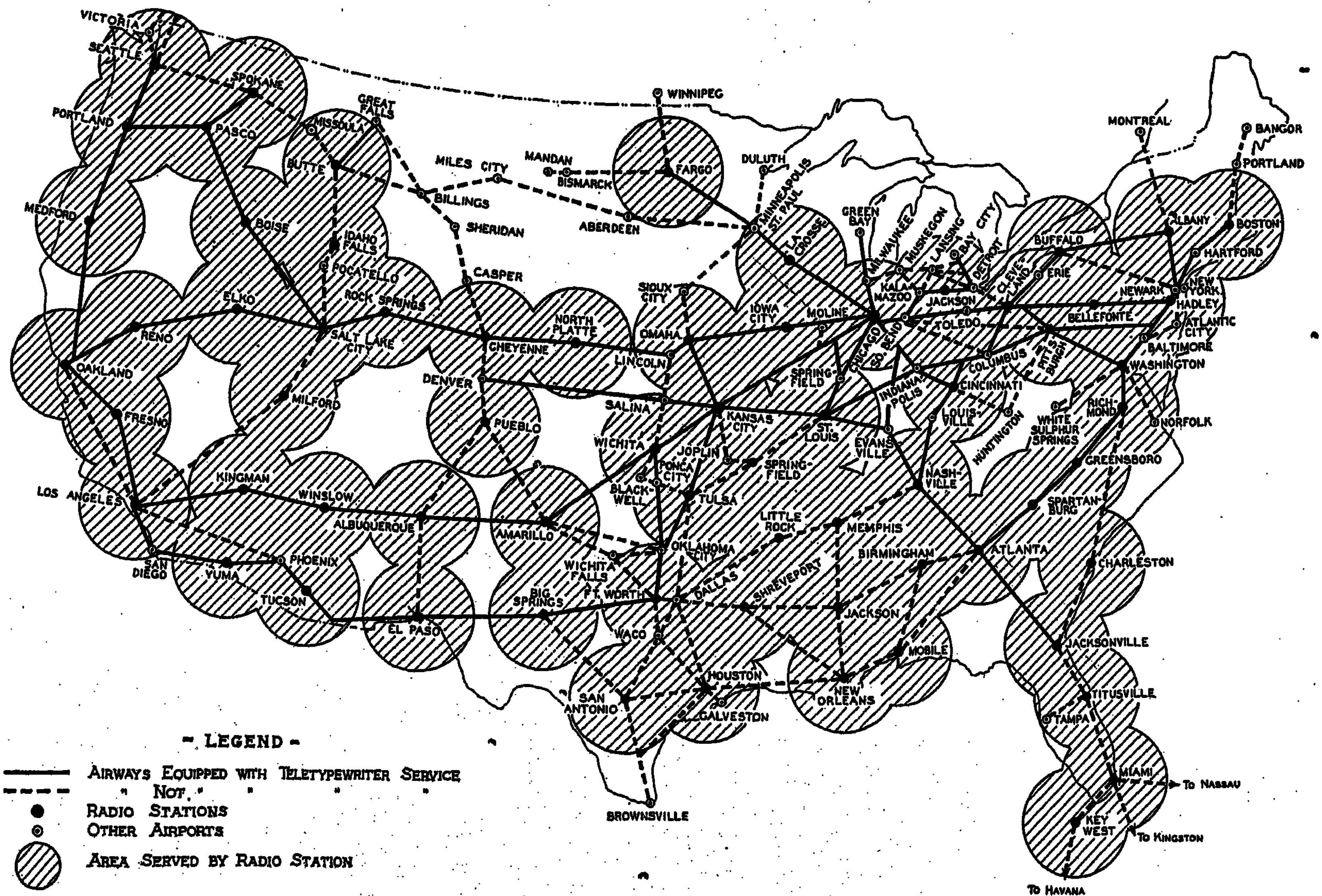
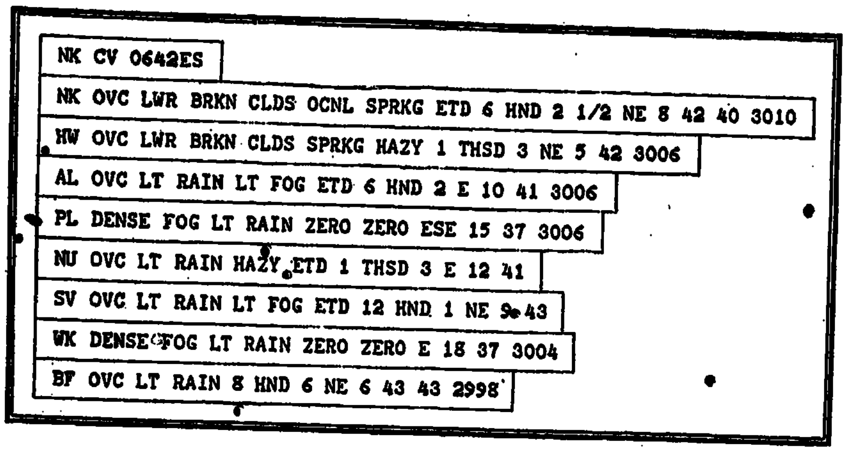


**Fig. 1. Map showing principal airways of the United States indicating routes equipped with teletypewriter service. Note large area served by radio**



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NK CV 0642ES
NK OVC LWR BRKN CLDS OCNL SPRKG ETD 6 HND 2 1/2 NE 8 42 40 3010
HW OVC LWR BRKN CLDS SPRKG HAZY 1 THSD 3 NE 5 42 3006
AL OVC LT RAIN LT FOG ETD 6 HND 2 E 10 41 3006
PL DENSE FOG LT RAIN ZERO ZERO ESE 15 37 3006
NU OVC LT RAIN HAZY ETD 1 THSD 3 E 12 41
SV OVC LT RAIN LT FOG ETD 12 HND 1 NE 9 43
WK DENSE FOG LT RAIN ZERO ZERO E 18 37 3004
BF OVC LT RAIN 8 HND 6 NE 6 43 43 2998
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Fig. 2. Portion of a typical weather sequence report as transmitted by teletypewriter

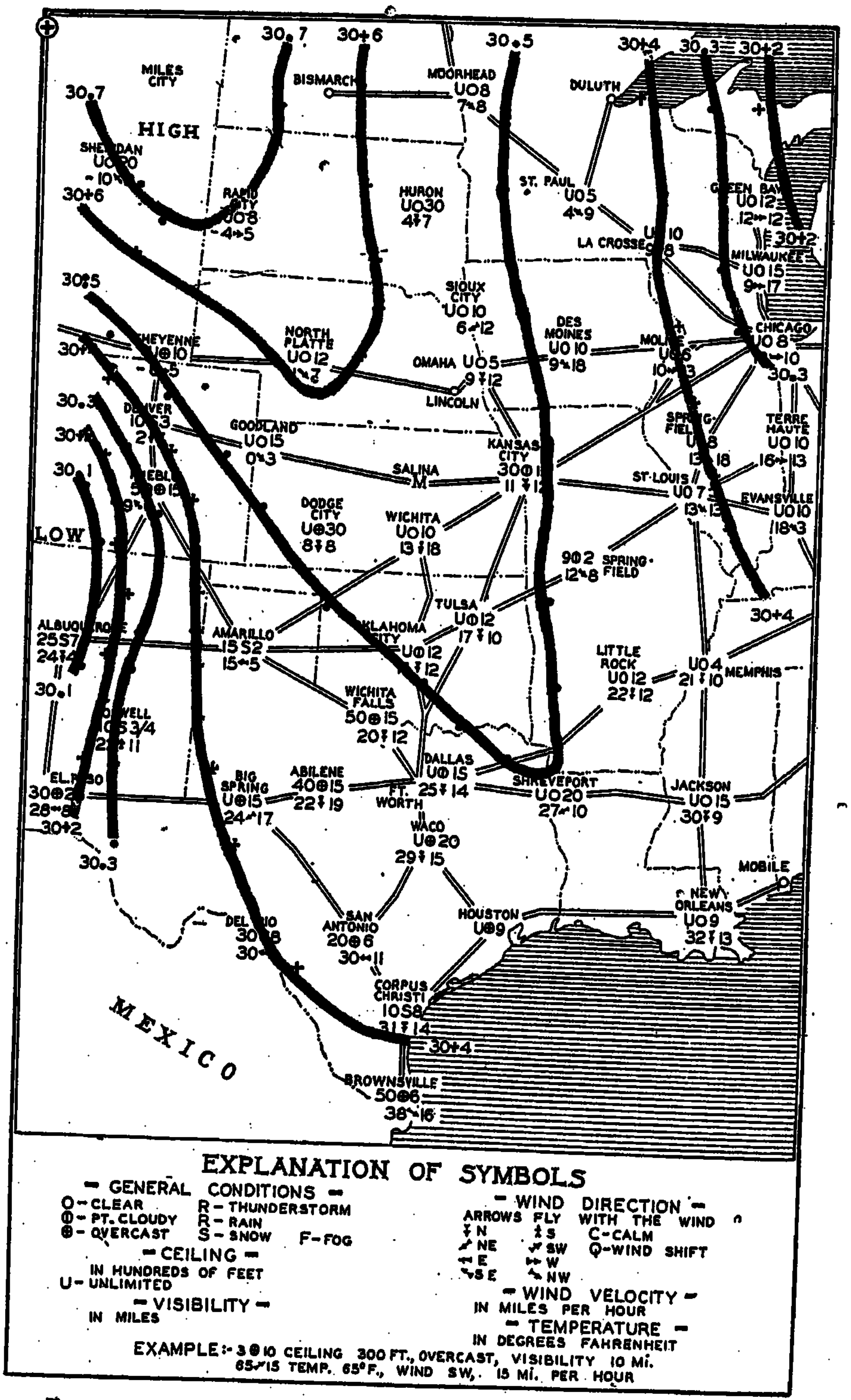

Fig. 3. Specimen weather map transmitted from 1 of the larger airports. A page teletypewriter with special characters is used for this purpose

ber of stations, the communications being automatically recorded at each point. A message using code or abbreviations can be sent instantly without the necessity of calling or checking with the receiving stations, thus requiring the immediate attention of only the sending operator. Automatic recording reduces the possibility of human error and permits the most efficient use of operating personnel with resulting savings in labor. Furthermore, as contrasted with radio, this system utilizing wire transmission is not so subject to variations in meteorological conditions; it is thus more dependable, and has the further advantage that it can be extended readily to handle large volumes of business. This system also is well adapted to carrying on administrative and other work as well as to weather reporting and plane dispatching.

## Transmission of Weather Reports

Notable progress has been made in reducing the effect of weather hazards to air transportation, through the service rendered by the United States Department of Commerce and weather bureau in the collection and dissemination of weather reports, supplemented by other reports collected by individual transport companies from planes in flight. A system of practically continuous reporting and forecasting for areas along air routes has been developed, and general weather observations have been extended to include data of particular benefit to air navigation. The teletypewriter networks furnished to the Department of Commerce are devoted largely to this purpose; in conjunction with the department's radio telephone broadcasting service these networks provide the means for furnishing to pilots information relating to existing conditions and forecasts for both general and local areas.

Twelve selected weather bureau airport stations located at strategic points in the country's airway network prepare summaries of weather conditions in their own areas and make area forecasts every 3 hours based upon data collected over the Department of Commerce circuits from connected airway stations, and over commercial telegraph lines from other reporting points. These summaries and forecasts then are transmitted over the teletypewriter circuits and made available to all airway stations.

While the forecasts include predictions as to storm developments or movements, conditions in specific localities often are likely to change rapidly; hence to keep pilots continuously advised of conditions likely to be encountered, it has been necessary to provide additional hourly reports along the air routes. Consequently, the airway keepers and weather bureau observers at the various teletypewriter stations make local observations of general weather conditions, ceiling height, visibility, wind direction and velocity, temperature, and barometric pressure, every hour. These data then are sent by the teletypewriter and automatically recorded at all points on the circuit in accordance with a predetermined schedule, which is coordinated with the broadcast schedule of radio stations. Since pilots will tune in on particular stations at definite times, it is important that the schedule be adhered to closely.

Fig. 2 shows a portion of an actual tape record of an hourly report along the Newark-Cleveland route. For convenience the tape has been cut to show 1 station report on each line. First, the starting time, 0642 E. S., which is 6.42 a.m. Eastern Standard time, is shown. This is followed by a report of observations from each station given in sequence. The time of actual transmission for all 14 stations, Newark to Cleveland, would be about 4 min. and at 6.50 a.m. the reports would be broadcast as scheduled from the radio stations on that route.

Based upon the information obtained through the sequence collections, the airway weather reporting stations retransmit, generally by teletypewriter, hourly weather reports to the various airway operating companies' offices in that vicinity where the information is posted for convenience to pilots. An experimental service involving the transmission of weather summaries in map form was tried out recently at Kansas City, Chicago, Cleveland, Newark, and Washington. A separate circuit equipped with page teletypewriters at each of these points was provided for this purpose. The weather maps were prepared at Kansas City and Cleveland every 3 hours and then transmitted over this circuit. A typical map transmitted from Kansas City is shown in Fig. 3. The map data are sent in sequence from the 2 transmitting stations; after they have been recorded on the map forms at the receiving station several duplicate copies can be run off immediately and the 2 maps fitted together if desired. The maps then are available to pilots at each of the respective airports.

Complete reports of weather generally are maintained by transport companies in dispatching offices. On some lines 2-way short-wave radiotelephone equipment has been provided for communicating with planes, periodic contact being maintained during flight. In this way pilots report their positions directly to dispatchers; in addition supplementary weather data usually are exchanged, particularly with respect to local ceiling heights and conditions in the upper air strata.

## PLANE DISPATCHING AND OTHER SERVICE

Teletypewriter circuits furnished to air transport companies are used principally for dispatching planes and handling the many traffic matters usual to this type of service. Plane movements including reports of position in flight are transmitted over the teletypewriter system and recorded at various offices, the reports of positions in many cases being given by pilots over short-wave radiotelephone where this type of equipment has been provided.

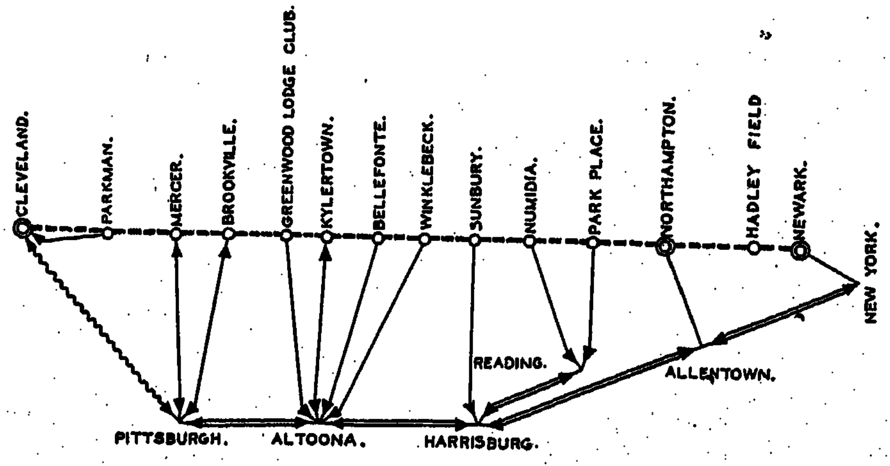

**Fig. 4. A typical teletypewriter circuit for airway service**

Intermediate airway stations often are situated some distance from main communication lines. A total of 846 miles of line thus is required to serve this 400-mile airway

To facilitate position reporting some of the companies have superimposed a system of rectangular coordinates over a map of the course cutting the territory into squares or rectangles 10 to 20 miles on a side. The coordinates are numbered so that the pilots and dispatchers can establish readily the location of the plane. Dispatchers generally maintain a typewritten, chronological log of position reports from each plane in the air. Bulletin boards also are used, marked with stations along the route and with spaces for filling in data such as plane number and license, name of pilot, time of arrival and departure at each station, and final destination.

On large lines a great deal of information is required to be transmitted in connection with the handling of traffic. Usually this consists of data concerning reservations, number of passengers and amount of mail and express carried, connections to be made, and arrangements at terminals. Supplementary instructions to pilots and many administrative matters requiring prompt handling also are transmitted.

Although airways teletypewriter circuits furnished to the Department of Commerce are used mostly for handling weather reports, considerable information also is transmitted relating to departure and arrival of planes and the positions of planes in flight. The Department of Commerce upon request will send over its teletypewriter system the license number of a plane, the station from which the plane is departing, its time of departure, and its destination, to stations along the route of the flight. Personnel of stations on this route knowing approximately the time due, then watch for the plane and record the actual time it passes so that other stations may be informed.

## TELETYPEWRITER CIRCUIT LAYOUT

Teletypewriter networks furnished by the Bell system for service along airways are composed of some 30 separate circuits. Circuit mileage of the longest is about 2,000 miles and of the shortest, 200 miles. The longer circuits generally connect 15 to 20 intermediate stations. Since airways naturally follow direct air lines the intermediate airway stations often are situated at points somewhat distant from main communication lines. (See Fig. 4.) At the larger airports such as Newark and Cleveland, local teletypewriter circuits also are provided to connect the Department of Commerce station with the offices of the various transport companies, the post office, and the weather bureau. Automatic transmission equipment is provided so that information received on 1 circuit can be retransmitted over 1 or more circuits as desired. Cable circuits, being less susceptible to interference and storm trouble than open wire circuits, where available have been used generally for establishing teletypewriter circuits furnished both to the Department of Commerce and to the transport companies. At present, over one-third of the mileage of these circuits is in cable. Facilities on alternate routes are available to be substituted for the regular circuit in the event circuit trouble develops.

### TELETYPEWRITER EQUIPMENT

Theory of teletypewriter operation has been described in other papers and hence will not be reviewed here. Tape and page type sending and receiving teletypewriters commonly used in this country are also used in airways service. Tape machines are particularly suited for this purpose since messages are usually short, and weather reports from the various stations can be conveniently posted by cutting and pasting the tape as desired. In addition to the ordinary sending and receiving machines, however, supplementary apparatus units may be used so that operators can work at maximum efficiency and the line circuit can be used to its maximum capacity. These units are the perforator, the tape transmitter, and the reperforator.

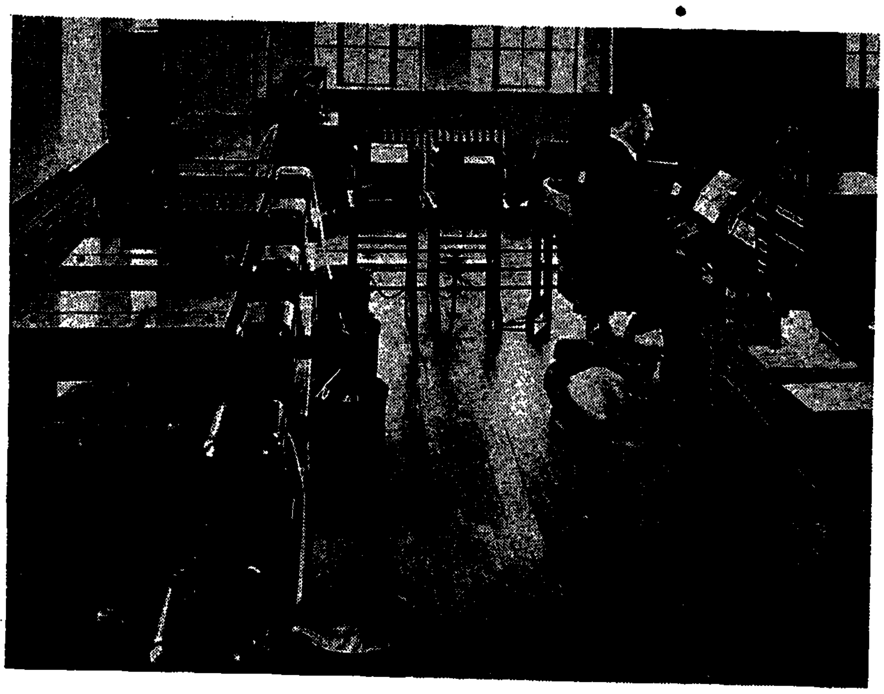

Fig. 5. A typical airport teletypewriter installation

The perforator is associated with a keyboard and perforates a tape with from 1 to 5 perforations for each key struck; the tape then is run through a tape transmitter which automatically sends electrical impulses to the circuit corresponding to the perforations in the tape and identical to those that would have been sent from the keyboard sending. Use of the perforator and tape transmitter permits the circuit to be operated at its maximum speed at all times and permits the operator to work in spurts and rest or do other work while the accumulated tape is running through the transmitter. Also the same tape can be run through several tape transmitters and thus can be used for sending the message over several circuits.

The reperforator is a receiving device which records the message on a perforated tape similar to that produced by a perforator unit. This permits storing a received message for immediate or subsequent retransmission to other circuits without retyping it.

The smaller teletypewriter stations of the Department of Commerce and those of the various transport companies generally are provided with one or two teletypewriters. At the larger stations of the Department of Commerce a special arrangement of equipment has been provided to permit efficient operation of the circuits from the standpoints of requiring the fewest operators and of obtaining rapid retransmission of messages received on 1 circuit to 1 or more of the other circuits, as required. A view of a typical installation is given in Fig. 5. The apparatus is mounted on tables specially designed for the purpose; these tables usually are arranged on the floor in the shape of a "U," the units facing inward so that the operators work inside the "U."

The arrangement of equipment generally permits 1 operator to attend all of the circuits. The teletypewriters are all installed in a fairly small space, which permits 1 man to observe the incoming messages, and to operate the control boards, to start and stop the proper transmitter, and to relay messages as required.

### RADIO INTERFERENCE

Establishment of teletypewriter stations along airways brought about the installation of teletypewriter equipment in the same room with, or in close proximity to, short-wave radio receivers; this introduced a problem in specific cases of radio interference caused by teletypewriter operation.

Remedial measures have been adopted effectively to reduce this interference and consist of the use of synchronous motors, rectifiers, and specially designed filters, together with the locating of the apparatus and wiring in such a way as to effect a minimum coupling between the teletypewriter and its associated loop, and the radio antenna system.

### CONCLUSION

History of air transportation in the past few years indicates that continued growth may be expected, particularly as hazards to flying are mitigated and as safety and dependability are recognized by the public. The government is continuing the extension of airways, weather reporting, and other services; and air transport companies are progressing in the development of transport business.

Fast and reliable communication service has proved to be the backbone of weather and position reporting, and has been a valuable aid in the handling of traffic and other matters relating to air transportation. Teletypewriter circuits used for land service have been found particularly suited to meeting the various requirements involving simultaneous communication with many stations at remote distances. Other wire communication services such as long distance telephone and commercial telegraph also have aided, particularly in reaching points not served by teletypewriter circuits. It is expected that wire communication service will continue to be used extensively in connection with air transportation, and will be of considerable aid in its future development.

# Stray Load Losses of a 55,000-Kva. Generator

Calorimeter tests on a 55,000-kva. hydro-electric generator show that the difference between stray load losses measured under load conditions and those measured under short-circuit conditions is slight. The method used by the authors is said to be applicable in general to all large units where an enclosed system of ventilation is used.

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IN ACCORDANCE with the A.I.E.E. standards, stray load losses of synchronous machines are determined with low excitation and with the machines short-circuited. There is still some question, however, as to whether this gives a true measure of the stray load losses under load conditions. In order to obtain a comparison between these losses on short circuit and under rated load, a series of thermal or calorimeter tests were made on one of the hydro-electric generators at the Queenston station of the Hydro-Electric Power Commission of Ontario, Canada. The machine tested is the last one installed and is rated as follows: 55,000 kva., 80 per cent power factor, 12,000 volts, three phase, 25 cycles, 187.5 r.p.m. The results showed but little difference between the losses measured on short circuit and those measured at rated load, the latter being slightly larger.

## METHOD OF TESTING

In general the method followed in making the tests was to operate the unit under several different conditions until the temperature of the cooling air, stator iron and stator copper became constant in each case; great care was taken to measure these quantities accurately, especially the temperature of cooling air. As the accuracy of these tests depends upon the accurate measurement of ingoing and outgoing air temperatures, high grade thermometers calibrated and graduated to 0.2 deg. cent. were used. For measuring the temperature of the outgoing air from the generator, ten of the thermometers were placed at the point where this air enters the cooler; ten thermometers also were used to ascertain the temperature of the air at the point where it leaves the cooler. Other thermometers were used to measure the temperature of the stator iron, the steel wall of the chamber enclosing the unit, the air outside this chamber, and the inlet air to the unit. To determine the temperature of the stator copper, thermocouples placed in the stator slots were used. Electrical readings of current, voltage, and power were taken with portable meters of good accuracy.

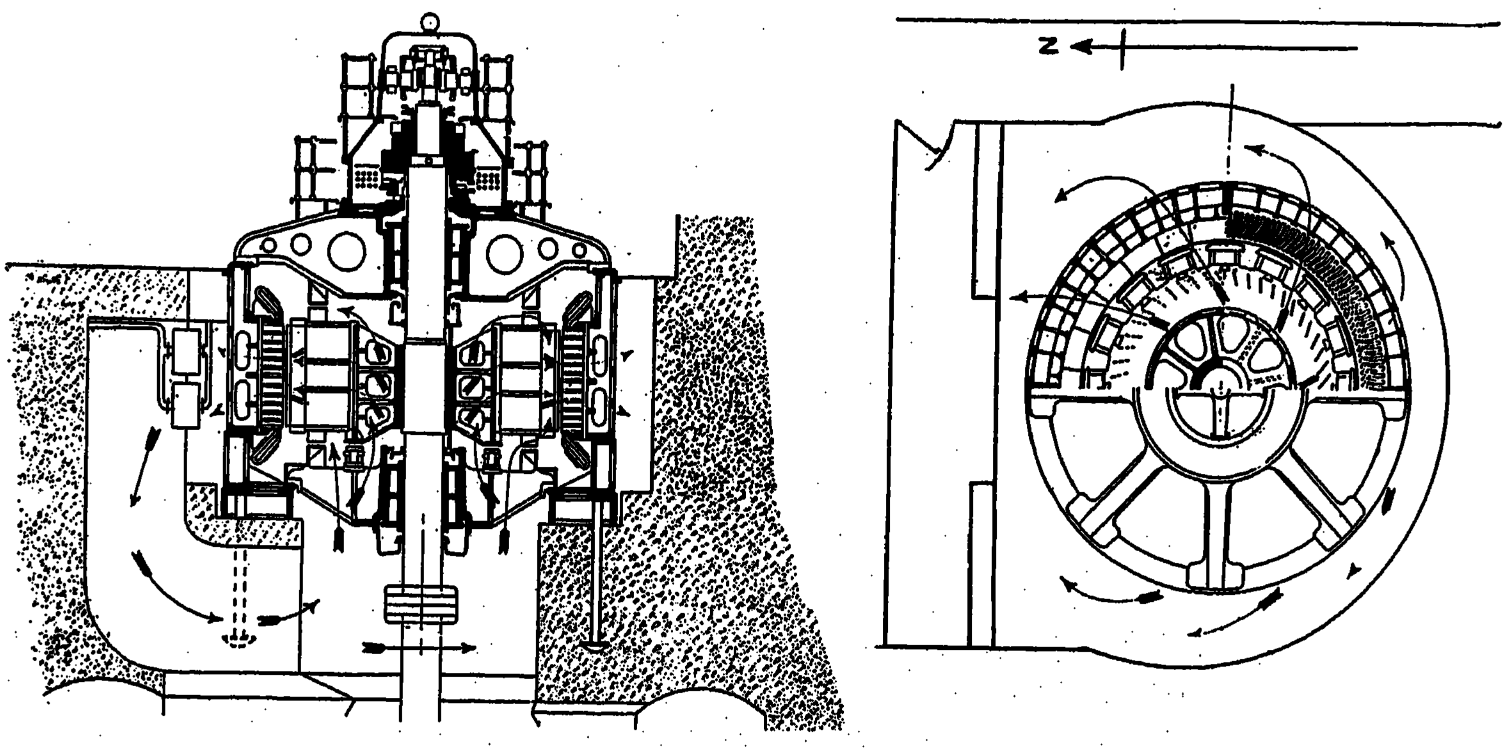

Fig. 1. Cross-section of 55,000-kva. generator for which stray load losses were determined; note completely closed ventilation system

Four different tests were made as outlined in the following paragraphs:

### Test No. 1—Windage Loss

For this test the unit was operated for 20$^1/_2$ hr. without excitation, starting with the machine hot. Temperature readings were taken during the first part of the run for a period of 5 hr.; at the end of

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Based upon "Calorimeter Measurement of Stray-Load Losses of 55,000-Kva. Generator Having Enclosed System of Ventilation" (No. 31-126) presented at the A.I.E.E. Pacific Coast convention, Lake Tahoe, Calif., Aug. 25-28, 1931.

the run two additional readings were taken, these giving the temperature rise due to the windage loss.

### Test No. 2—Core Loss

For this test the unit was operated at synchronous speed without load, but with sufficient excitation to give 12 kv. at its terminals. This test extended over a period of 7 hr., temperature readings being taken throughout the run.

### Test No. 3—Short-Circuit Test

On this test the unit was operated at its rated current of 2,650 amperes under three-phase short circuit. In this test it was found difficult to hold the stator current constant on the unit, the exciter being a direct-connected shunt-wound machine; thus small variations in speed caused corresponding variations in the excitation and in the short-circuit current. No special arrangements were made to control the excitation of the unit; had this been done perhaps the accuracy of the test could have been increased a small degree.

### Test No. 4—Test at Rated Load

This test was made in two parts, (a) with a water rate of 500 gal. per min. through the coolers, and (b) with 400 gal. per min. through the coolers; both tests were made at approximately rated load. In order to complete the test in a minimum time the unit was operated for 8 hr. at approximately rated load, during which time no temperature readings were taken. The load then was set accurately as close to rated conditions as could be obtained and held, after which temperature readings were taken over a period of 3 hr. at $^1/_2$-hr. intervals. For the second portion of this test, the water rate was adjusted to 400 gal. per min., and temperature readings taken for an additional $4^1/_2$ hr. at $^1/_2$-hr. intervals.

## RESULTS AND CALCULATIONS

The results of the four tests are shown in Figs. 2 to 5, inclusive. Tests No. 2 and 4 are of particular interest. For Test No. 2, the results are quite consistent and indicate that the temperatures of the unit and the temperature rise of the air can be found accurately; however, the test must be continued long enough to allow the temperatures of all parts of the machine to reach a constant value. It may be noted that the temperature of ingoing air to the unit rises along with the temperature of the unit itself; also that the air, iron, and copper temperatures arrive at a constant condition at the same time.

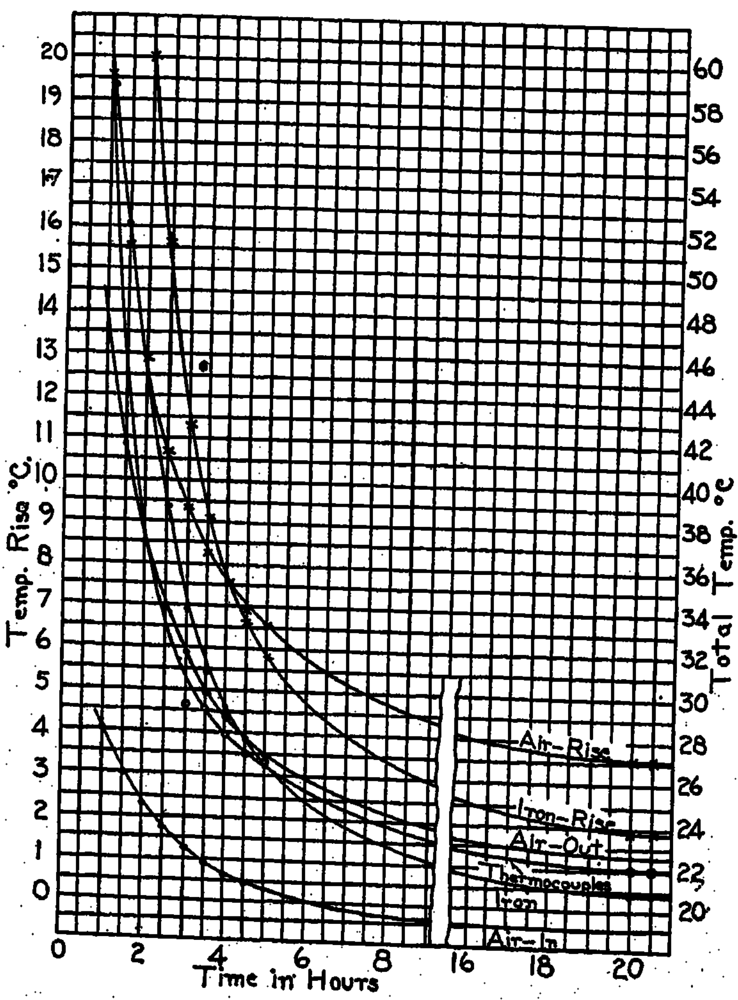

Fig. 2. Cooling curves for windage loss test (No. 1)

Test No. 4 indicates the accuracy with which the temperature measurements were made, and the effect of changing the water rate through the coolers. It may be noted from Fig. 5 that immediately following the adjustment of water rate, changes in temperature occurred which, although not great, were quite definite. The curves show also that a period of $4^1/_2$ hr. was required to bring the unit back to new constant temperatures differing from the previous ones by approximately $1^1/_2$ deg. The temperature rise of the air and of the iron, however, were the same values for both water rates.

Stray load losses are determined by the difference between the total losses as calculated from the temperature rise of the air and the known losses. The method of determining these losses from the test results is as follows: Temperature rise due to windage only is given by the results of Test No. 1, while Test No. 2 gives the rise due to windage and core loss; the difference between these two values obviously gives the rise due to core loss only. Since the core loss is known from other tests, a constant $K$ may be calculated giving the kilowatt loss per degree rise. With the aid of this constant, the loss for any other operating condition may be determined directly from the air rise.

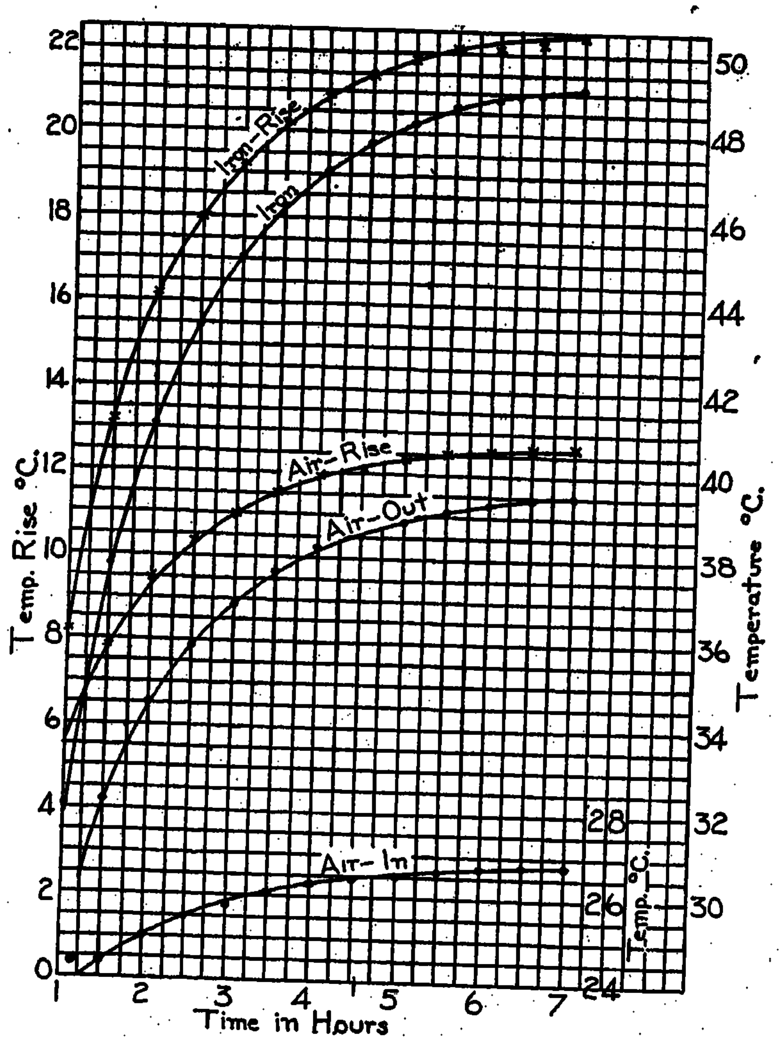

Fig. 3. Heating curves for core loss and windage test (No. 2)

| | |
|---|---|
| Terminal potential.................... | 12,000 volts |
| Field current.......................... | 314 amperes |
| Collector ring potential................ | 98 volts |

These calculations involve the following temperature assumption: In an enclosed ventilating system where heat is being generated at a constant rate and the air is being cooled in coolers using a constant flow of water, the loss converted into heat is proportional to the temperature rise of the air, after all conditions have become constant. It is evident that the crux of the method is that all conditions must be constant. Among other things this requires that the humidity and barometric pressure must not change during any series of tests. If the pressure were to drop appreciably, the constant $K$ would be affected, and it would be necessary to repeat the *windage* and the *windage and core loss* tests, in order to obtain reliable results; also, a constant $K$, determined under certain atmospheric conditions, obviously cannot be used with the results of tests under different atmospheric conditions.

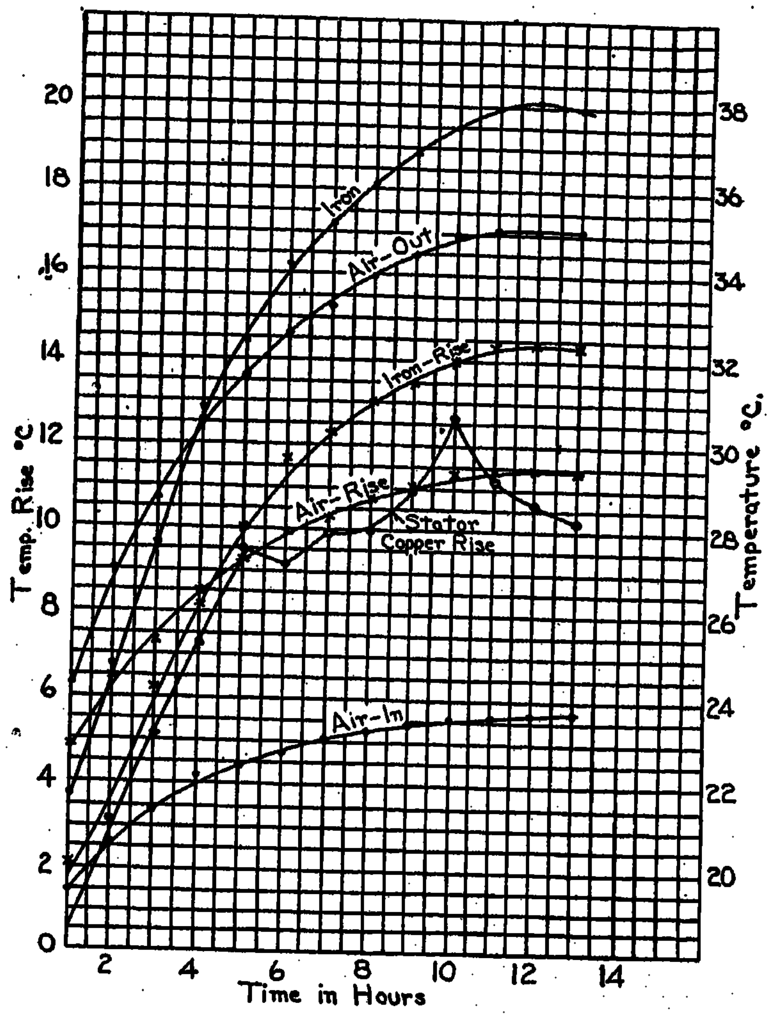

**Fig. 4. Heating curves for short circuit tests (No. 3)**

| | |
|---|---|
| Armature current | 2,650 amperes |
| Field current | 320 amperes |
| Collector ring potential | 98 volts |

Losses thus computed from these tests are shown in Table I. As a check on these results, losses computed from the heat absorbed by the cooling water are shown also in Table I. These figures are in remarkably close agreement when it is considered that the thermometers used in the cooling water were read to the nearest half degree only.

As a further refinement an attempt was made during the various tests to determine the amount of heat lost from the shell surrounding the generator. Temperatures of the shell and of the surrounding air were determined and the radiation loss calculated; these values are shown also in Table I as are recalculated values of the various losses taking into account these radiation losses. These latter calculations indicate that the radiation loss makes but a very small difference in the losses measured in this test, probably less than the experimental error associated with the test itself.

Stray power losses determined from the short-

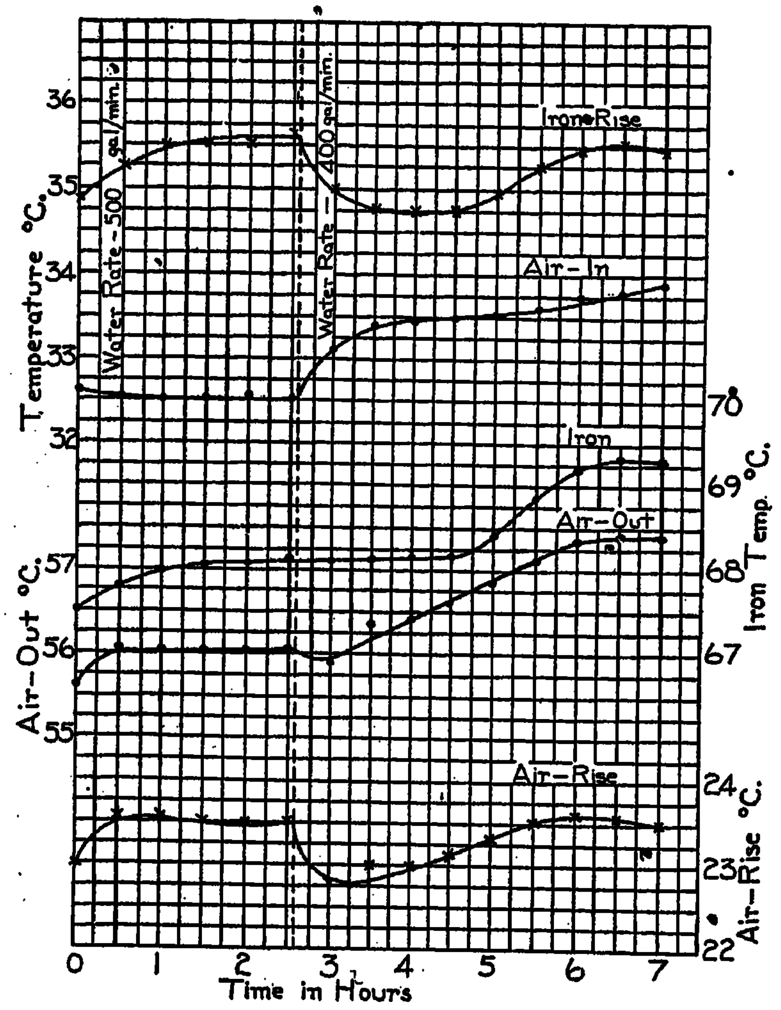

**Fig. 5. Heating curves for rated load tests (No. 4)**

| | (a) | (b) |
|---|---|---|
| Water rate | 500 gal. per min. | 400 gal. per min. |
| Armature current | 2,580 amperes | 2,610 amperes |
| Terminal potential | 12,070 volts | 11,900 volts |
| Load | 43,400 kw. | 43,200 kw. |
| Field current | 608 amperes | 612 amperes |
| Collector ring potential | 229 volts | 234 volts |

**Table I—Losses Computed From Test Results**

| | Computed Losses in Watts | | | |
|---|---|---|---|---|
| Test No. | From Air Temperature Rise | *From Heat Absorbed by Cooling Water | Radiation Losses | Calculated Losses Allowing for Radiation |
| 1 | 152 | — | 0 | 149 |
| 2 | 538 | 475 | 7 | 535 |
| 3 | 483 | 475 | 4 | 479 |
| 4(a) | 990 | 1,030 | 16 | 987 |
| (b) | 990 | 1,010 | 16 | 987 |

* Thermometers accurate only to 0.5 deg. cent.

**Table II—Comparative Stray Load Losses for Short-Circuit and Rated-Load Tests**

| Test No. | Computed From Air Temperature Rise (Watts) | Computed Losses With Allowance for Radiation (Watts) |
|---|---|---|
| 3 (short circuit) | 108 | 104 |
| 4 (rated load) | 138 | 135 |

circuit (No. 3) and rated-load (No. 4) tests are shown for comparison in Table II; these are shown with and without provision for radiation losses.

## CONCLUSIONS

Results of these tests indicate that for this particular type of unit, the stray load losses under short circuit and at rated load are approximately equal. The stray load losses are about 50 per cent of the stator copper loss at rated load. The results indicate also that if sufficient care is taken in measuring the temperatures, the stray load losses can be determined with fair accuracy on large units when an enclosed system of ventilation is used. The great drawback appears to be the time necessary to make a complete series of tests, although it is possible that a compromise test over a short period of time could be made and the final temperature rise of the air determined by calculation. The results obtained by Laffoon and Calvert (A.I.E.E. TRANS., v. 46, 1927, p. 84–98) from calorimeter tests on turbine-generators agree with the results of these tests in that the stray load losses under load conditions are shown to be slightly higher than under short-circuit conditions. A logical conclusion seems to be then that if an accurate determination of the losses is required, a test under load conditions is justified; but for most purposes, a test under short-circuit conditions seems to be sufficient.

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# Characteristics of a Mercury Vapor Tube

**Results of an investigation of the grid and plate currents in a grid-controlled mercury-vapor tube show that the direction of grid current in these tubes depends not only upon the instantaneous polarity of the grid, but also upon the magnitude of both the grid voltage and the plate current. It is shown also that inverse plate current flows whenever grid current is flowing during the negative half cycle of plate voltage.**

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INCREASING use of grid-controlled mercury-vapor tubes for regulation, control, and rectification, makes desirable a study of certain characteristics of these valves which, judging from the literature available, have not as yet received the attention they deserve. The behavior of plate and grid currents, especially the latter, in some instances may inhibit the proper functioning of the tube and cause it to fail to play its proper rôle in the circuit.

One of the few investigators who has published his findings on the subject is Nottingham (*Journal*, Franklin Institute, v. 212, 1931, p. 271) who studied the grid and plate currents of these tubes chiefly under conditions prior to discharge. He found, as might be expected, that before the cathode-to-anode discharge takes place, the tube behaved as a gaseous triode. From preliminary experiments it became evident that some interesting studies were possible by investigating the plate and grid currents under various conditions of discharge. Accordingly, a series of tests was conducted using a typical mercury vapor tube of this type; the results point to the following conclusions:

1. The instantaneous direction of current flow in the grid circuit of a grid-controlled mercury-vapor tube depends not only upon the instantaneous polarity of the grid with respect to the cathode, but also upon the magnitude of the effective grid potential and upon the plate current.

2. The grid current may consist of positive loops only, of positive and negative loops of varying areas or equal areas, and of negative loops only, depending upon (*a*) the magnitude of the effective grid potential which determines whether or not the grid is able to repel positive ions when it is instantaneously positive, and electrons when it is instantaneously negative; and (*b*) the magnitude of the plate current which determines the degree of ionization present.

3. A d'Arsonval meter cannot be used in the grid circuit to determine the value of grid current, since the grid current wave generally has both positive and negative loops; in the extreme case where these loops are equal, such a meter would indicate zero current, although there might be an alternating current of considerable magnitude flowing.

4. When the grid voltage lags the plate voltage, the positions of the positive and negative loops of grid current may be transposed by merely varying the grid voltage.

5. An inverse plate current of the order of milliamperes always is present when grid current is flowing concurrent with the negative half cycle of plate voltage. When the grid current during the negative half cycle of plate voltage is zero, the lag of deionization of the mercury vapor allows some ionization to be present when the plate voltage changes to negative, thereby yielding a minimum, but not zero, value of inverse plate current.

6. With constant average grid current, the inverse plate current varies approximately sinusoidally with the angular displacement between the grid and plate voltages.

7. Formation of the positive ion sheath that envelops the grid and causes cathode-to-anode discharge is inhibited at low alternating grid voltages, by electrons having sufficient kinetic energy to enter the grid when it is at an instantaneous negative potential. For consistent operation the grid voltage employed to initiate discharge should be several times the critical voltage of the tube.

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Written especially for ELECTRICAL ENGINEERING: *Not published in pamphlet form.*

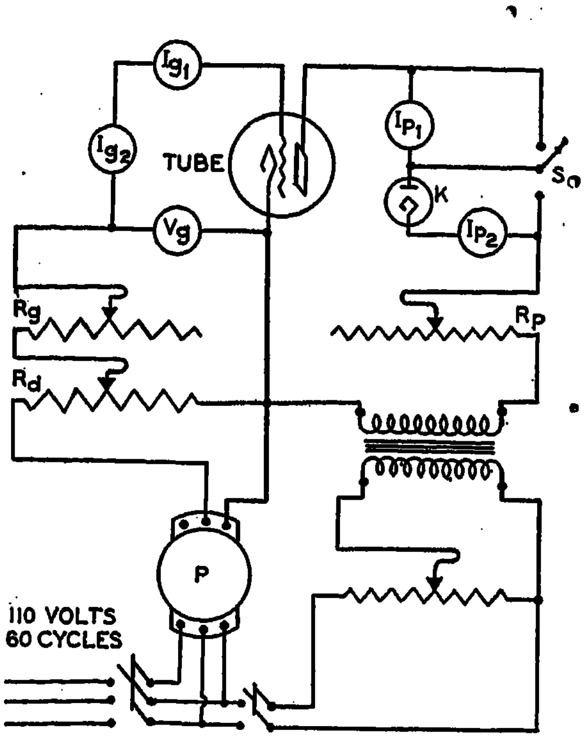


**Fig. 1. Circuit diagram for determining characteristics of grid-controlled mercury-vapor tubes**

## Test Procedure

The tube used for this investigation was a General Electric type FG-29, air-cooled thyratron, intended for use as a controlled rectifier. The cathode of this tube is of the uni-potential coated type, the heater of which requires a current of 12 amperes; this was supplied from a special filament transformer. The tube is designed for a maximum forward and inverse potential of 3,500 volts, and a maximum average plate current of 12.5 amperes.

The circuit employed in the tests is shown in Fig. 1. The plate of the tube was energized from a 110/1,100-volt transformer. Voltage for the grid, variable in magnitude and phase, was obtained by means of a potential divider $R_d$ which in turn was connected to one phase of a three-phase phase-shifter $P$. All tests were carried out at a frequency of 60 cycles and, unless otherwise stated, at an r.m.s. plate potential of 1,100 volts.

For measuring average values of the grid and plate currents d'Arsonval meters $I_{g1}$ and $I_{p1}$ were used; the effective value of the grid current was measured by a heater-thermocouple instrument $I_{g2}$. A dynamometer voltmeter $V_g$ was connected directly between grid and cathode to measure the grid voltage. Inverse plate currents were measured by a d'Arsonval instrument $I_{p2}$. By throwing switch $S$ to the upper position, the positive loop of plate current was blocked by tube $K$, a two-element high-vacuum rectifier. Resistances of the grid and plate circuits were varied by variable resistors $R_g$ and $R_p$, respectively.

In the oscillograms reproduced* it was thought more expedient to give the average and effective values of grid currents in lieu of placing current scales on the oscillograph traces themselves. Using a three-element oscillograph, two photographs for each condition were taken in order to include the four variables, grid voltage ($V_g$), grid current ($I_g$), plate voltage ($V_p$), and plate current ($I_p$); all four quantities have been shown together, however, by inking the wave of $V_p$ on the oscillograms showing the other three values.

## Grid Voltage in Phase With Plate Voltage

When the grid voltage is in phase with the plate voltage and is sufficiently high to repel electrons when the grid is instantaneously negative, the grid current wave consists of positive loops extending over the positive half cycle of the grid voltage wave. Under these conditions the grid current follows the shape that would be expected from a two-electrode mercury-vapor valve, but its wave is modified considerably with very low grid potentials. The oscillogram in Fig. 2 shows that with $V_g = 5$ volts (r.m.s.) the grid current is completely negative and exhibits two peaks. During the first portion of the positive half cycle of grid voltage, positive ions were able to enter the grid and thereby give rise to negative grid current; as the grid voltage reached its maximum positive value, the grid was able to repel the positive ions and attract electrons the net effect of which was to reduce the negative grid current to zero; however, as the grid voltage decreased from its maximum positive value, positive electrons again were able to enter the grid, thereby setting up another negative peak of grid current.

An increase of 1 volt in $V_g$ removes the second negative loop of $I_g$ shown in Fig. 2, and causes this portion of $I_g$ to become positive; this is demonstrated in Fig. 3, the plate current and grid resistance being

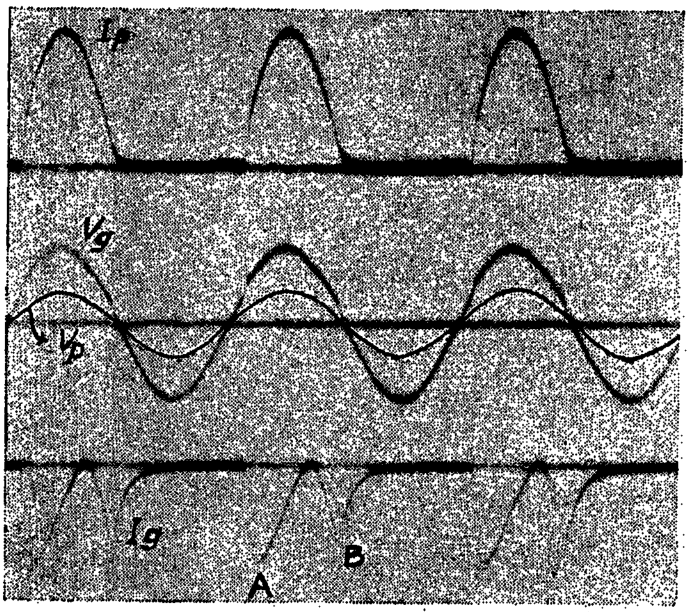


Fig. 2 (left)

$V_g$ = 5 volts (r.m.s.)
$I_g$ = 100 milliamperes (avg.)
$R_g$ = 100 ohms
$V_p$ = 1,100 volts (r.m.s.)
$I_p$ = 1.2 amperes (avg.)

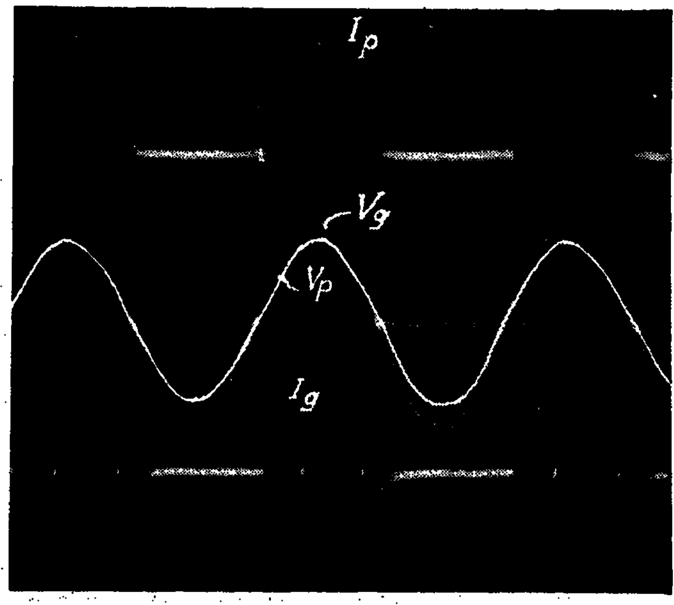


Fig. 3 (right)

$V_g$ = 6 volts (r.m.s.)
$I_g$ = 0 (avg.)
$I_g$ = 3 milliamperes (r.m.s.)
$R_g$ = 100 ohms
$V_p$ = 1,100 volts (r.m.s.)
$I_p$ = 1.2 amperes (avg.)

**Fig. 2 (left) and 3 (right). Voltage and current relations with plate and grid voltages in phase**

maintained at the same values as in Fig. 2. It may be observed that the increase in $V_g$ from 5 to 6 volts enabled the grid to attract enough electrons, as $V_g$ traversed its maximum values in its positive half cycle, to set up a positive loop of $I_g$, the area of which was equal to the area of the negative loop; thus the average grid current was zero, but the effective value was 3 milliamperes. As the grid voltage is increased beyond 6 volts, the negative loop of grid current decreases and the positive loop increases, until finally the grid current consists solely of positive loops.

From the foregoing it would be expected that if the average value of grid current were plotted against grid voltage, the curve first should have negative values, then reverse itself and later become positive. That this actually takes place may be seen from Fig. 4, where such curves have been drawn for three values of plate current with the plate and grid voltages in phase. From 0 to 3.75 volts the grid currents were too small to show on this plot, but their behavior in this region has been described by Nottingham (*loc. cit.*). The cathode-to-anode discharge took place at 3.75 volts. At this point, ionization caused by the flow of plate current furnished positive ions of sufficient velocity to enter the grid and make the areas of the negative loops exceed the area of the positive loop, as in Fig. 2.

For a given grid voltage the average value of the negative grid current depends upon the degree of ionization, i. e., upon the plate current; hence the 5-ampere curve shows the greatest negative value of average grid current, and the 10 milliampere curve, the smallest. As the grid voltage is increased, the positive loop of grid current also increases and the negative loops decrease, causing the curves to attain a negative maximum and return to zero. All three curves cross the zero axis in the region where the grid voltage equals from 6.5 to 7 volts; this is the region where the positive loop of grid current is equal to the negative loop as in Fig. 3. The positive loop of grid current increases also with ionization; hence above the zero axis the three curves lie above each other in the order of magnitude of their corresponding plate currents because the positive loop of grid current increases with plate current as well as with grid voltage; the negative loops finally disappear. Thus the curves cross as they intersect the zero axis and reverse in order.

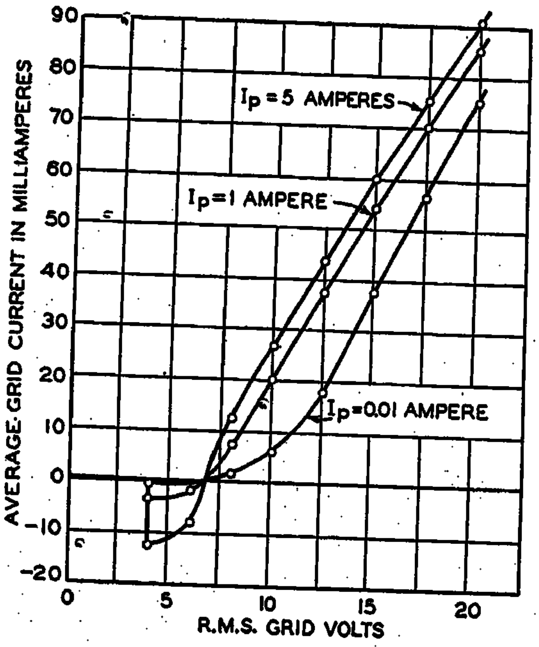


**Fig. 4. Grid voltage-current relations with grid and plate voltages in phase**

$V_p$ = 1,100 volts
$R_g$ = 100 ohms

## Grid Voltage Leading Plate Voltage

When the grid voltage leads the plate voltage, the grid is positive before the tube begins to discharge. When the grid voltage becomes negative, the tube is discharging, positive ions are available, and hence the wave of grid current becomes negative. In Fig. 5 the grid voltage is shown leading the plate voltage by 90 deg. Grid current starts flowing when the grid becomes positive, then rises to a maximum, and falls to zero with the grid voltage. When the grid voltage becomes negative, the tube is still discharging and hence still generating positive ions. These positive ions enter the negative grid forming a negative loop of grid current which increases with the instantaneous value of grid voltage; this increase continues until the plate current is reduced to zero, when the source of positive ions disappears. At this point the negative grid current falls rapidly to zero, and remains so until the grid voltage becomes positive again in the following cycle. Thus, while the first half of the positive loop of grid current occurs before the tube discharges, the entire negative loop occurs while the plate current is flowing. From

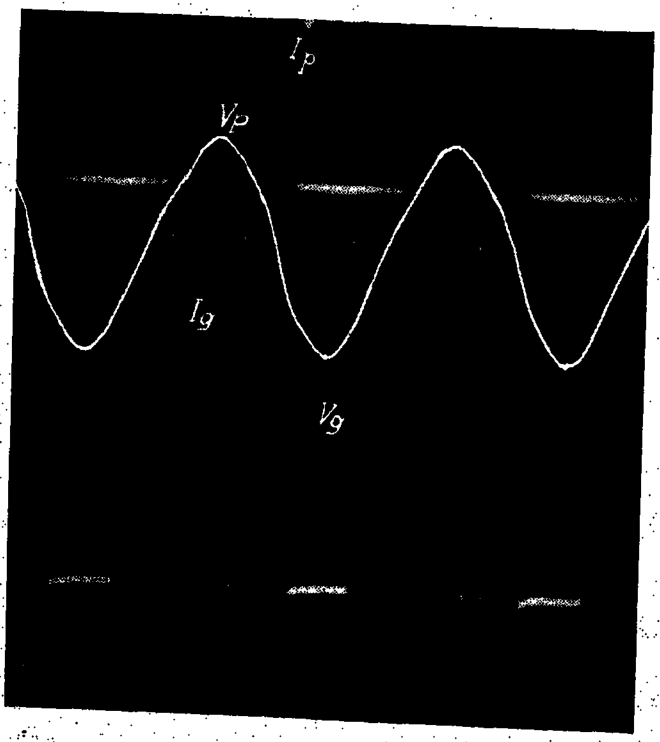
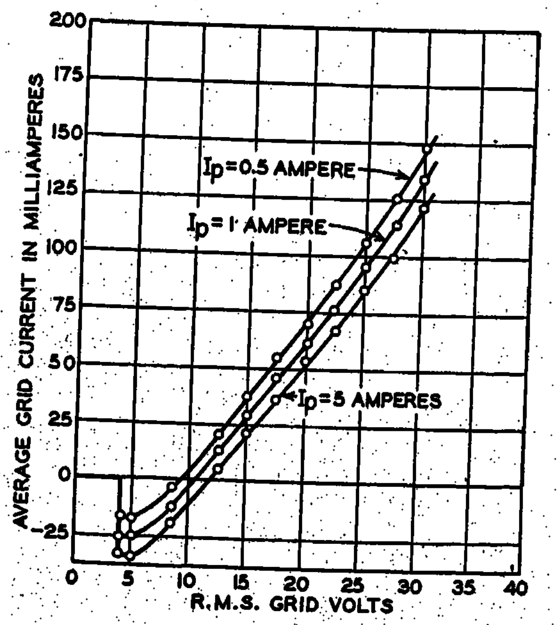


**Fig. 5. (Left) Voltage and current relations with the grid voltage leading the plate voltage by 90 deg.**

$V_g$ = 40 volts (r.m.s.)
$I_g$ = 275 milliamperes (avg.)
$I_g$ = 600 milliamperes (r.m.s.)
$R_g$ = 100 ohms
$V_p$ = 1,100 volts (r.m.s.)
$I_p$ = 4 amperes (avg.)

**Fig. 6. (Right) Grid voltage-current relations with the grid voltage leading the plate voltage by 90 deg.**

$V_p$ = 1,100 volts, $R_g$ = 100 ohms



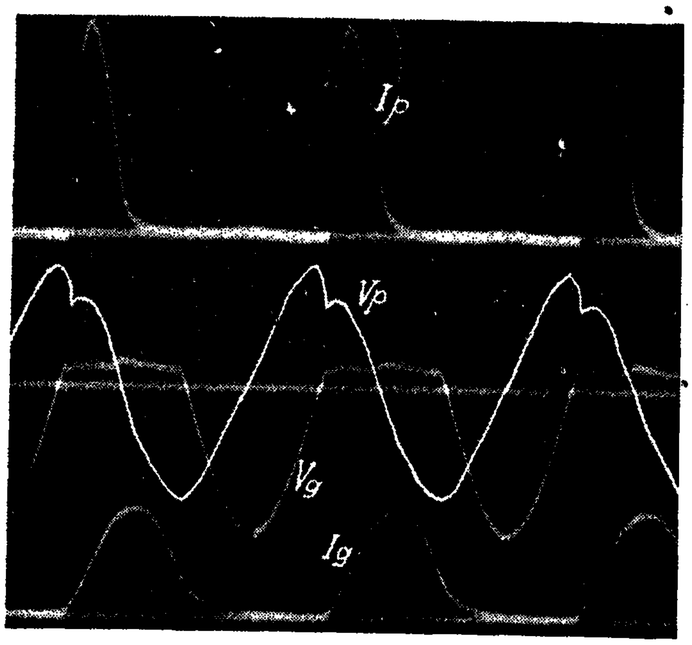


Fig. 7 (left)

$V_g$ = 30 volts (r.m.s.)
$I_g$ = 165 milliamperes (avg.)
$I_g$ = 220 milliamperes (r.m.s.)
$R_g$ = 100 ohms
$V_p$ = 1,100 volts (r.m.s.)
$I_p$ = 1.5 amperes (avg.)

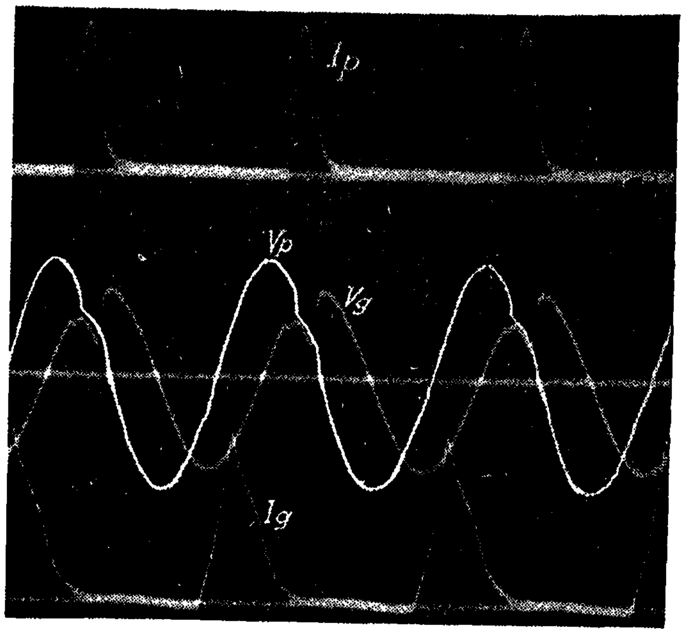


Fig. 8 (right)

$V_g$ = 6 volts (r.m.s.)
$I_g$ = 6 milliamperes (avg.)
$R_g$ = 100 ohms
$V_p$ = 1,100 volts (r.m.s.)
$I_p$ = 1.2 amperes (avg.)

**Fig. 7 (left) and 8 (right). Voltage and current relations with the grid voltage lagging the plate voltage by 90 deg.**

this it would be expected that with a decrease in grid voltage the negative loop would grow faster than the positive loop.

If the grid voltage be reduced to small values, the negative loop of grid current decreases more slowly than the positive loop, and the average grid current becomes negative. Variation of the average grid current with grid voltage, with the grid voltage leading the plate voltage by 90 deg., is shown in Fig. 6. Shapes of the curves are similar to those obtained with grid and plate voltages in phase, with the exception that the curves do not cross each other and reverse their order as they intersect the zero axis (see Fig. 4). From 0 to 3.75 volts the grid currents were too small to plot, as in Fig. 4. At 3.75 volts, the tube discharged and the grid currents became negative, the negative values for a fixed grid voltage increasing with the plate current. This is due to the negative loop of grid current increasing with the increase in ionization afforded by the increase in plate current. As the grid voltage increases, the curves attain their negative maxima and return to zero in the interval where the grid voltage equals from 9 to 12 volts. Above the zero axis, the curves for the lower plate currents assume higher positions, i. e., for a fixed grid voltage the average value of grid current decreases with plate current; the loops of negative grid current increase with plate current. At the same time, a large portion of the positive grid current flow occurs before the tube discharges. The result of this is that with increase in plate current for a given grid voltage the negative portion of grid current grows more rapidly than the positive portion, and the average grid current decreases with an increase in plate current. For this reason the curves do not reverse their order as they cross the zero axis.

## GRID VOLTAGE LAGGING PLATE VOLTAGE

Behavior of the grid current when the grid voltage lags the plate voltage by 90 deg. is shown in the two oscillograms reproduced as Figs. 7 and 8. In Fig. 7, $V_g$ was maintained at 30 volts. During the negative loop of grid voltage, no plate current flows because no positive ions are present and the grid current is zero. When the grid becomes positive, a positive grid current begins to flow increasing to a maximum value, then decreasing gradually to zero after the grid voltage has become zero. The discharge has ceased since the plate voltage has become negative; thus there is no source of positive ions for the negative grid and accordingly the grid current remains at zero until the grid becomes positive in the next cycle.

If the grid voltage be reduced to a much lower value than in Fig. 7, the positive loop of grid current will be found to shift its position from the second quarter cycle (counting from the instant when the plate voltage becomes positive) to the first quarter cycle. An oscillogram for this condition is presented in Fig. 8, where $V_g$ was reduced to 6 volts. Comparing Figs. 7 and 8, the positive loop of grid current apparently has shifted from the quarter-cycle during which the tube discharges, to the quarter-cycle of positive plate voltage during which there is no discharge. In Fig. 8, although the grid voltage is low, no electrons enter the grid by virtue of their velocities during the fourth quarter-cycle when the grid is negative, because of the negative potential of the plate. During the first quarter-cycle, however, the plate voltage is positive and electrons coming from the cathode are able to impinge upon the grid although the grid is at a negative potential with respect to the cathode; thus a positive loop of grid current is formed during the first quarter-cycle. The total current produced by electron emission from the cathode entering the grid is small compared with the ionization available for producing grid currents when the tube is discharging. Accordingly, the magnitude of the positive loop of grid current for a grid potential of 5 volts is small compared with that for a grid potential of 30 volts, the average grid currents in the two cases being 5 and 165 milliamperes, respectively.

Referring to Fig. 8 again, when the grid voltage becomes positive and discharge begins, the resultant ionization produces positive ions of sufficient velocity to enter the grid, although the grid is at a low positive potential and is receiving electrons from the filament. The net result is that the grid current is reduced to zero and remains so until the plate voltage becomes positive in the following cycle. If the voltage of the grid was lowered still further, the grid current in the second quarter cycle would not only be reduced to zero, but would be depressed to a negative value by the positive ions generated by the plate current.

## Inverse Plate Current

Whenever the grid voltage either lags or leads the plate voltage, grid current flows during part of the negative half cycle of the plate voltage; when the grid voltage leads the plate voltage, the initial portion of the grid current flow occurs when the plate voltage is negative; when the grid voltage lags the plate voltage, grid current is flowing when the plate voltage changes from positive to negative. Whenever grid current is flowing, positive ions are available because of ionization of the mercury vapor. Hence whenever grid current is concurrent with negative plate voltage a negative loop of plate current should be present. The oscillograms presented thus far show no negative loops of plate current because of the disparity in magnitudes between the positive loops and the negative loops, the latter of which have their origin in the comparatively small amount of ionization afforded by the grid current.

When the phase displacement between the plate and grid voltages is 175 deg., a positive loop of grid current flows when the plate voltage is negative; this condition is illustrated in Fig. 9 where the average value of plate current was reduced to 13 milliamperes by plate circuit resistance to bring out the negative loop more prominently. With fixed plate voltage, the magnitude of inverse plate current depends upon the magnitude of grid current flowing when the plate is negative. When the potential of the grid is sufficiently high to prevent electrons from impinging upon the grid when it is negative, and likewise to prevent positive ions from entering the grid when it is positive, the grid current follows the grid voltage with a certain lag. From this it follows that with a constant average grid current, maintained by adjustment of grid voltage, the variation of inverse plate current with phase displacement between grid and plate voltages should be approximately sinusoidal. In Fig. 10 are plotted values of negative plate current against angular displacement between grid and plate voltages, for three constant values of average grid current. These curves follow quite closely the form $A + B \cos(\theta - \alpha)$ where $\theta$ is the angular displacement between the grid and plate voltages, $\alpha$ is the angular displacement between the grid voltage and current, and $A$ and $B$ are constants. Sinusoidal variations computed on the basis of maximum values of the observed currents coincide with the experimental curves obtained, except for a short section of the curve for an average grid current of 0.2 ampere; that portion of the computed curve which deviates is shown by a broken line. Data for these curves were taken by throwing switch $S$ in Fig. 1 to the upper position, thereby blocking the positive loops of plate current by tube $K$ and reading the average values of inverse current on milliammeter $I_{pi}$. The plate potential was maintained at 1,100 volts (r.m.s.) and the plate circuit resistance when the inverse plate current was flowing was the plate resistance of tube $K$, a type KM-1 kenotron.

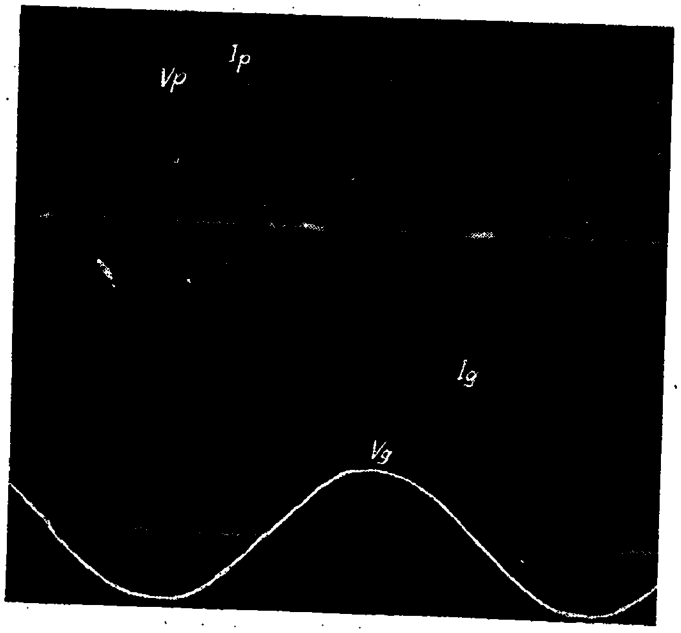


Fig. 9. Voltage and current relations with the grid voltage leading the plate voltage by 175 deg. Note inverse plate current

$V_g$ = 60 volts (r.m.s.)
$V_p$ = 1,100 volts (r.m.s.)
$I_g$ = 790 milliamperes (avg.)
$I_p$ = 17 milliamperes (avg.)
$R_g$ = 50 ohms

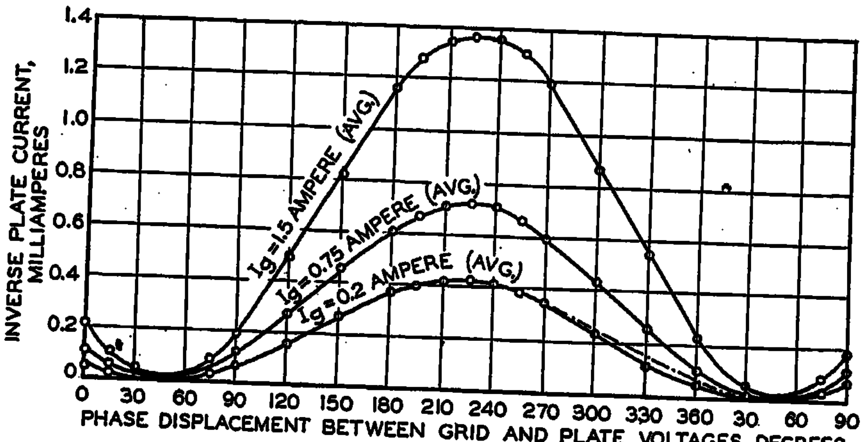


Fig. 10. Inverse plate current as a function of phase displacement between grid and plate voltages

The grid current in the inverse current tests lagged the grid voltage by approximately 40 deg.; from this it would be expected that the inverse plate current would be at its maximum value when the positive loop of grid current coincides with the negative loop of plate voltage, that is, at 180 deg. + 40 deg. This is seen to be the case in Fig. 10. In the same way the minimum value of inverse plate current is shifted from the 0-deg. point by the same angular displacement. There is no null value of inverse plate current because when the positive loop of grid current is contained wholly within the positive loop of plate voltage, the plate becomes negative before deionization is complete; hence there is a small source of positive ions which yields a minimum but not zero value of negative plate current at that point.

From the foregoing it may be seen that no matter what the phase displacement between the grid and plate voltages may be, an inverse plate current always is present. Its minimum value is determined by the quantity of positive ions remaining, due to lag in deionization, when the plate potential reverses; its maximum value is determined by the magnitude of grid current flowing when the plate voltage is negative.

Two tubes of the same type were studied and only slight variations of magnitude in the phenomena described were observed. Because the number of tubes was limited to two, the characteristics presented are not set forth as average characteristics of grid-controlled mercury-vapor tubes, but merely as typical of this particular type of tube.

# Insulator Performance Studied by Flashover Tests

**Many factors affect the flashover characteristics of porcelain insulators; these characteristics in turn have a direct bearing upon insulator design and upon the choice of proper insulation for any particular purpose. In the following group of three articles by representatives of three of the leading insulator manufacturers, results of investigations made in this field by these manufacturers are given. In the past, many of the data for comparable insulators from different sources seemed conflicting. In these articles, however, reasonably careful study will reveal many points of agreement, when the results are reduced to a comparable basis. The first two articles deal with the effect of various factors on insulator sparkover characteristics; the third article deals with the flashover characteristics of suspension insulators, and also contains data relating to the cost and selection of economical suspension insulator assemblies.**

## I—Insulator Arcovers Versus Size and Humidity

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DATA covering the electrical characteristics of comparable insulators as received from different sources frequently are conflicting. In an attempt to clarify some aspects of this controversial subject, a study has been made to establish rules whereby such characteristics can be estimated from the dimensions of the insulators with a reasonable degree of certainty. Variations in the arcover potential of dry insulators due to the influence of humidity changes also are considered and approximate correction ratios given.

Conclusions of the study are based upon an extensive series of tests made in the high voltage laboratory of the Locke Insulator Corporation at Baltimore, Md. Throughout the tests all voltage measurements were made as prescribed in the A.I.E.E. Standards. All tests were made at a frequency of 60 cycles.

SUSPENSION INSULATORS

Tests were made on suspension insulators of both the cemented and Hewlett types, with unit spacings of from $4^3/_4$ to 7 in. and with diameters ranging from 10 to 12 in. It was found that within these dimension limits the flashover voltages of all insulators when dry fell upon one curve when plotted against actual arcing distance, the shortest air path between

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Based upon "Normal Frequency Arcover Values of Insulators as Affected by Size and Humidity" (No. 32-62) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14-16, 1932.

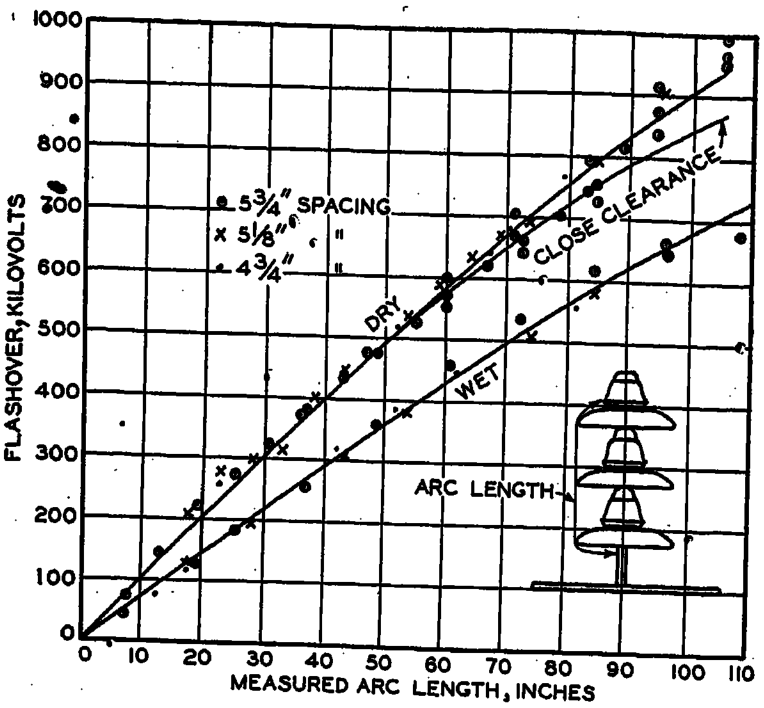
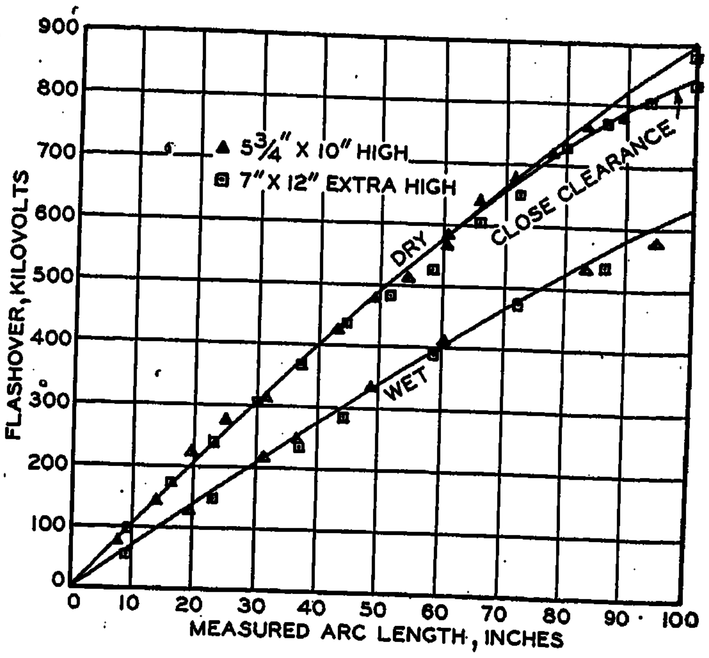


**Fig. 1. (Left) Flashover characteristics of 10-in. standard-strength suspension insulators**

**Fig. 2. (Right) Flashover characteristics of high-strength insulators**



electrodes. Flashover for voltages for wet insulators when so plotted showed some variation depending upon the design of the insulator. The curves of Figs. 1 and 2 show the dry and wet values for cemented type insulators plotted against actual arcing distance. Flashover voltages for dry insulators are affected by the proximity of grounded objects. This is shown by the double graph at the upper end of the dry curves, the upper graph being obtained with clearances at least twice the length of the insulator string.

For design purposes it is most usual to plot flashover voltages for wet insulators as a function of the wet striking distance or the summation of the air gap distances beneath the insulator, assuming that the wetted surfaces above are short-circuited out by the water film. A satisfactory check is so obtained as shown by Fig. 3. Expected arcover potentials for dry and wet suspension insulator assemblies are given in Figs. 4 and 5, plotted as a function of the number of units in the string, and calculated from Figs. 1 and 2.

Standard- and high-strength cemented insulators were tested also in the anchor position at an angle of about 10 deg. from the horizontal. Arcover voltages obtained for both dry and wet conditions are shown in Figs. 4 and 5 in comparison with corresponding values for the vertical assemblies. The "dry" arcover values are materially lower for the horizontal than for the vertical position; "wet" values, however, are much higher for the horizontal than for the vertical. This is because when the entire surface of the insulator is uniformly wetted, a better voltage division between insulator units is obtained with the resultant higher voltage necessary to cause breakdown. The "wet" values for the horizontal strings are actually equal to, and in some cases with long strings, higher than the "dry" values for the same position.

Most of the tests in the horizontal were made without a jumper loop under the string or a conductor at right angles to it. Insulators in the horizontal position with the conductor at right angles showed dry arcover potentials materially higher than without it, yet not equal to the values obtained for the vertical suspension insulators.

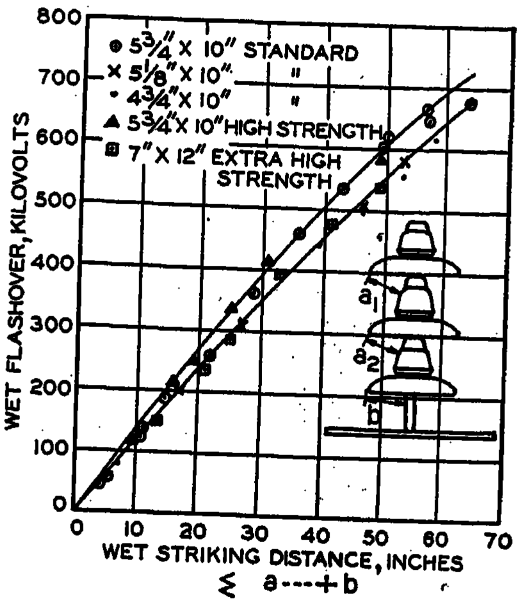


**Fig. 3. Flashover characteristics of all-cemented suspension insulators when wet**

## PIN INSULATORS

Standard pin insulators show fairly uniform arcover voltages in proportion to the distance between electrodes as shown in Fig. 6. The small contact area of tie wires upon the porcelain causes heavy dielectric flux concentration on the tie wires, with resultant active corona streamer formation at voltages near arcover. Because of the erratic action of these streamers, observed data show the least uniformity of any of the types of insulator tested.

It is interesting to note that more consistent comparisons of data for wet pin insulators are obtained on the basis of *total* striking distance rather than *wet* striking distance. The low sparkover voltages for the small one-piece insulators when wet are due to the large proportion of wetted surface to total striking distance.

## OUTDOOR APPARATUS INSULATORS

Outdoor apparatus insulators are pin types modified by adding cemented-on caps for attachments. In comparison with pin types these insulators show less variation between individual observations. This is brought about by the greater contact area of the cap, which causes less flux concentration and less corona streamer formation at voltages below flashover.

In Fig. 7 are shown flashover voltages of single and multiple unit insulators when both dry and wet; in both cases the results are plotted against actual arcing distance. As is shown, however, data for the wet condition are far more consistent when plotted against wet striking distance.

## Equipment Bushings

Performance of solid porcelain equipment bushings (not oil filled) is shown in Fig. 8 for ratings from 7.5 to 69 kv. The field established about the bushing determines its arcover potential when dry. In tests of this nature it is important that the conductor be in place inside the insulator as it will be in service, since much higher values are obtained without it. When the bushings are wet the arcover potentials are the breakdown voltages for the water film on the surfaces; for the larger bushings the values are higher when the insulator is wet than when dry.

## Humidity Effects

The effect of humidity upon the dry arcover voltages of insulators may be compared on several different bases as follows:

1. By a comparison of flashover values on the basis of per cent humidity. This is not satisfactory, for it alone does not account for the total quantity of water in the air.
2. By a comparison on the basis of absolute humidity or mass of water per unit of air volume. This method may be satisfactory, but does not account for the molecular activity of the water.
3. By a comparison of flashover on the basis of water vapor pressure in some convenient units such as inches of mercury in the barometric method. This accounts not only for the number of water molecules present, but for their velocity as well.

Throughout the common range of temperature the numerical difference between vapor pressure (expressed in manometric inches of mercury) and absolute humidity (expressed in grains per cubic foot) is so slight as to make no practical difference as to which is used as the basis. Water vapor pressure as the standard is recommended by the A.I.E.E. Standards (41-100); hence all observations in this portion of the investigation have been compared upon this basis.

Effects of humidity upon the dry flashover of standard suspension insulators are shown in Fig. 9. By plotting on semi-logarithmic paper equal ordinate distances give equal percentage variations. Thus it is easy to compare percentage corrections for different strings and percentage variations from the average of individual observations. The slope of all these average graphs is practically the same. When referred to 100 per cent at the standard water vapor pressure, 0.608 in. of mercury the correction at 0.2 in. of mercury is −8 per cent; the correction factor, therefore,

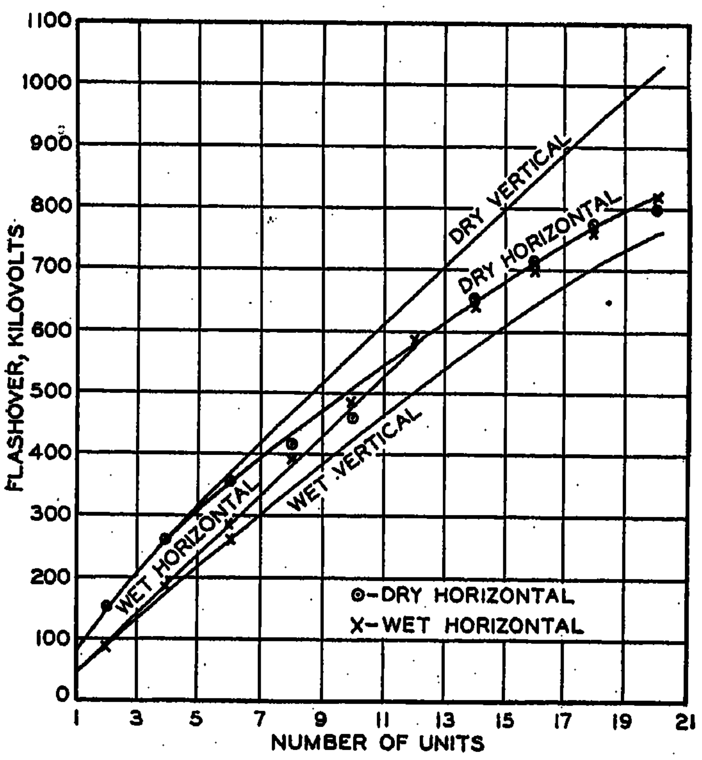


**Fig. 4. (Left) Flashover characteristics of insulator assemblies made up of 10-in. standard-strength units, spaced 5³/₄ in. apart**

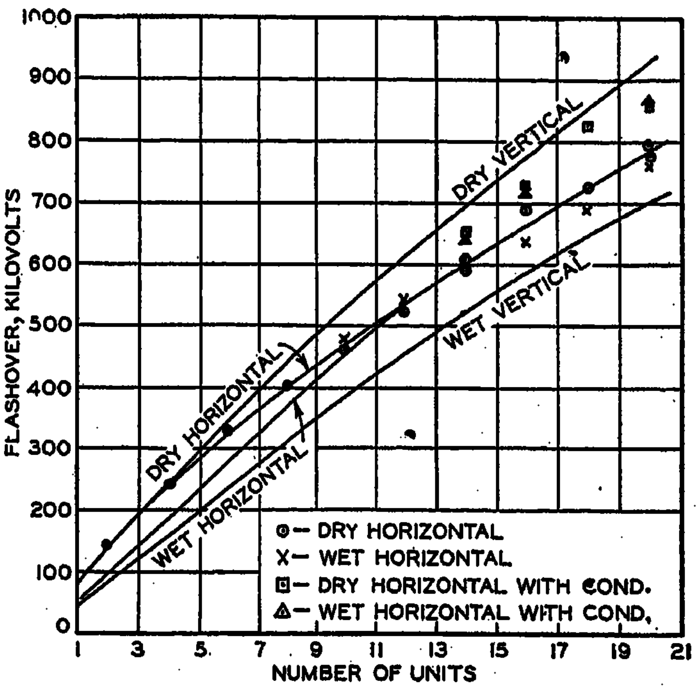


**Fig. 5. (Right) Flashover characteristics of suspension insulator assemblies made up of 10-in. standard-strength units, spaced 5¹/₈ in.**

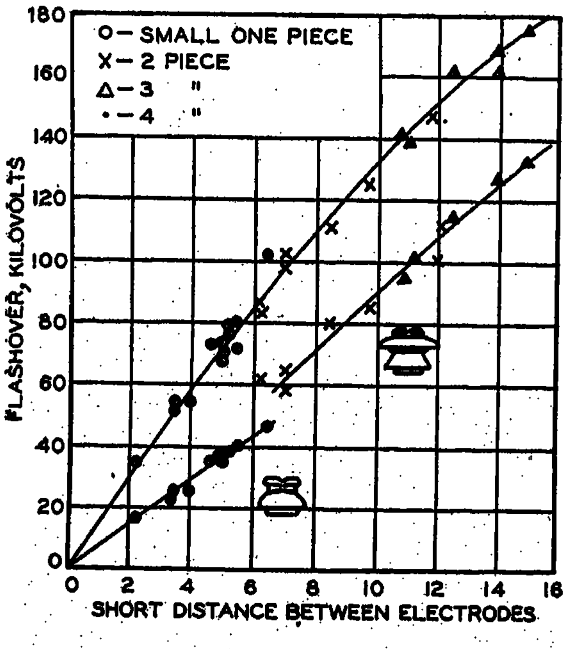


**Fig. 6. (Left) Flashover characteristics of pin insulators**

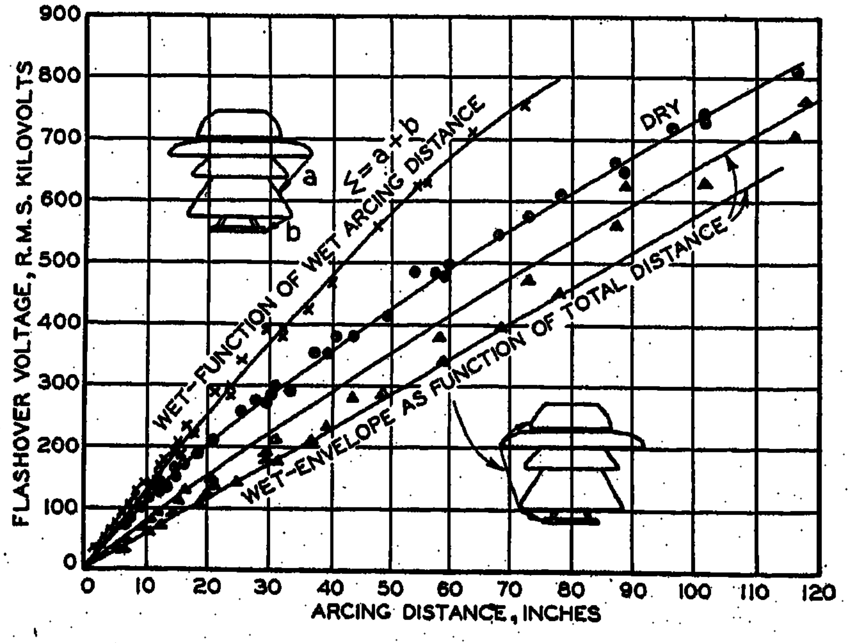


**Fig. 7. (Right) Flashover characteristics of outdoor apparatus insulators**

is approximately 2 per cent for each 0.1 in. of mercury variation in water vapor pressure.

As may be seen from Fig. 9, the points of observation would be inclosed within an envelope of plus and minus 5 per cent from the curve of averages. It follows, therefore, that even with the correction for humidity a variation of plus or minus 5 per cent in flashover values of suspension insulators must be expected.

Effects of humidity on flashovers of typical pin insulators are shown in Fig. 10. Only one insulator of each type was tested; thus the variations shown are not due to manufacturing variations in different insulators. The individual observations may be seen to lie within an envelope of plus or minus 6 per cent; the broadest variation of any type of insulator tested. The variation in flashover of all insulators between vapor pressures of 0.2 and 0.608 in. of mercury is about 12 per cent. Frequently in testing at standard temperature with a relative humidity above 65 per cent, erratic performance and marked fall in flashover voltage was observed. A typical example of this is shown for the 27-kv. insulator. Such behavior is believed to be due to the formation of an invisible water film upon the surface of the insulator at these higher humidities.

Tests were made also to determine the effect of humidity upon typical outdoor apparatus insulators. Compared with the pin types these insulators showed much more stable performance; this is due to absence of corona streamers as already discussed. Variation from the average curve is not over plus or minus 5 per cent, and the correction for humidity is 8 per cent between vapor pressures of 0.2 and 0.608 in. of mercury, the same as for suspension insulators, but less than for pin types.

Performance of porcelain equipment bushings with varying humidity also was investigated. The humidity correction for these bushings was found to be the same as for all others except the pin types.

### EFFECT OF SURFACE CONDITIONS

In an effort to determine how the above rules for insulator flashover might be affected by surface conditions, representative insulators were exposed for a period of several months above the smoke boxes of a battery of beehive kilns. At the expiration of this period the surfaces of these insulators were thoroughly covered with a dirt deposit consisting largely of carbonaceous material mixed with a certain amount of clay dust and ordinary floor dirt. Due to the baking action of the heat from the kilns the coating was rather hard. Other insulators of exactly the same type were thoroughly coated with a salt crust by spraying them with a concentrated salt solution and allowing them to dry.

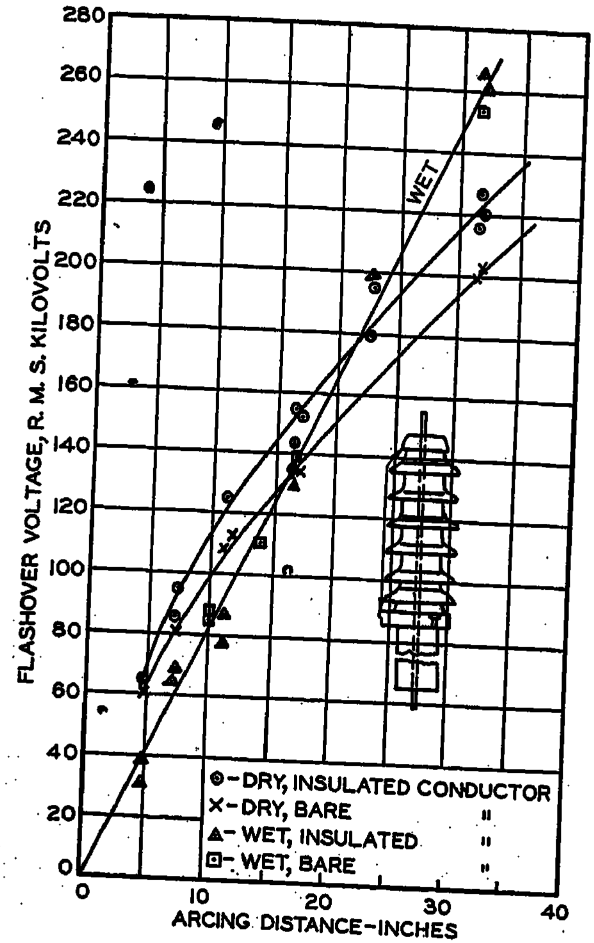


Fig. 8 (Left) Flashover characteristics of solid type equipment insulator bushings

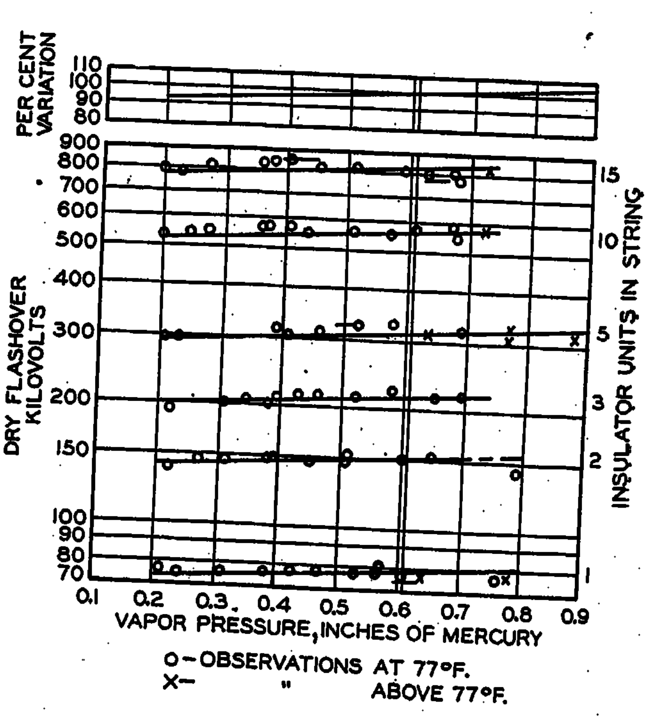


Fig. 9. (Right) Effect of humidity on the flashover voltage of standard suspension insulators

**Table I—Flashover Voltages of Dirty and Salt-Coated Insulators**

| Condition | 35-kv. Pin Type | 44-kv. Pin Type | One Unit 5³/₄ × 10 In. Disk | Three Units 5³/₄ × 10 In. Disk |
|---|---|---|---|---|
| Dry, clean, 65% Humidity | 120 | 135 | 77 | 204 |
| Dry, salt-coated, 79% Humidity | 97 | 97 | 34 | |
| Dry, salt-coated, 65% Humidity | 112 | 114 | 75 | |
| Dry, dirty, 65% Humidity | 116 | 128 | 69 | 205 |
| Wet, clean | — | 95 | 48 | |
| Wet, salt-coated | 34–63 | 52–80 | 27–44 | |
| Wet, dirty | — | 67–74 | 36–53 | |
| In steam fog, clean | 56 | 74.5 | 33 | 139 |
| In steam fog, salt-coated | 24 | 34 | 23 | |
| In steam fog, dirty | 48 | 68 | 32.5 | 114 |

These insulators then were flashed over, first clean and dry, then salt-coated and dry, and finally dirt-coated and dry. Tests were repeated with the insulators in a steam chamber filled with steam at a temperature of approximately 100 deg. fahr. to simulate fog conditions. Finally some of the insulators were tested as specified by the A.I.E.E. standard wet flashover test. Some typical results are shown in Table I.

It may be noted that there is but little reduction in the dry flashover voltage of the insulators when dirty. Dry tests on the salt-coated insulators were made at

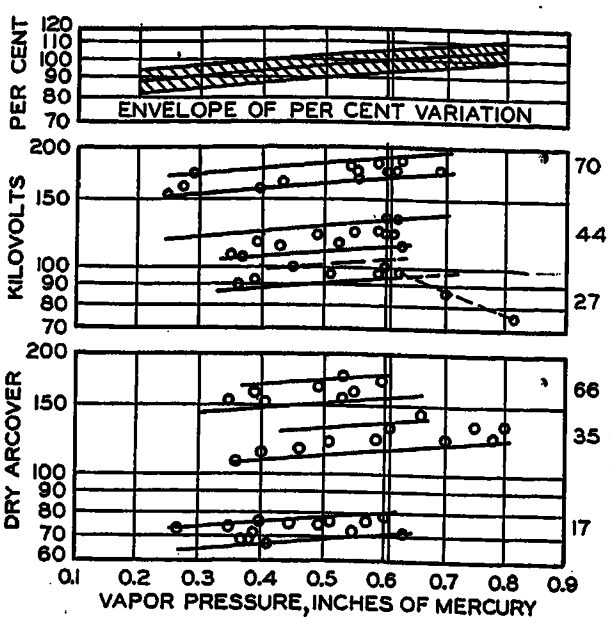
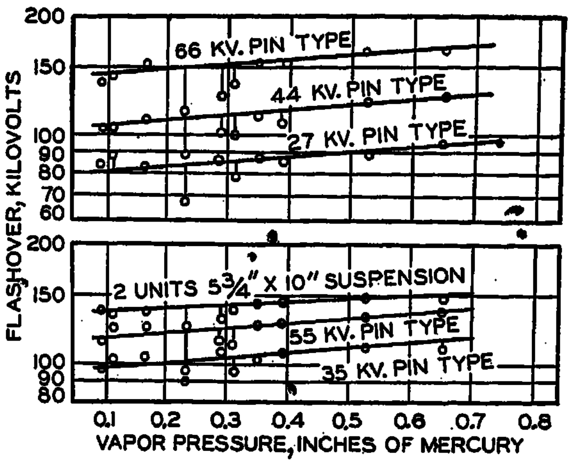


**Fig. 10. (Left) Effect of humidity on the flashover voltage of pin insulators**

**Fig. 11. (Right) Flashover voltages of dirty insulators as a function of humidity**



two humidity conditions. The first group of tests yielding the higher values in the tabulation was made at approximately 77 deg. fahr. dry bulb temperature, 65 per cent relative humidity. The second group of tests made at approximately the same temperature and at 79 per cent relative humidity gave flashover values materially lower, probably due to the absorption of moisture by the salt. At the lower humidity the dry flashover voltage of the salted insulators is nearly the same as that of clean insulators.

**Table II—General Summary of Test Data**

| Insulator Type | Dry Flashover Kv. per In. of Arcing Distance | Wet Flashover Kv. per In. of Arcing Distance | Wet Flashover Kv. per In. of Wet Striking Distance | Humidity Correction per 0.1 In. Mercury, Water and Vapor Pressure |
|---|---|---|---|---|
| Suspension (up to 100-in. string length) | | | | |
| Standard cemented | 10.5 to 9 | 7 to 6.8 | ——— | 2% |
| High-strength cemented | 10.5 to 9 | 7 to 6.3 | 14 to 10.6 | |
| Hewlett flat disk | 10.5 to 9 | 7.5 | | |
| Hewlett fish tail | 10.5 to 9 | 6.5 | | |
| Pin Types | | | | |
| Small one piece | 14 | 7.0 | ——— | 3% |
| Multi-part | 14 to 11.4 | 8.9 | Erratic | 3% |
| Apparatus insulators | 11 to 7.3 | 8 to 5.7<br>Erratic | 13 to 10.4 | 2% |
| Equipment Bushings | | | | |
| Solid type with insulated conductor | 13.6 to 6.75 | 8.3 | ——— | 2% |
| Solid type with bare conductor | 12.4 to 6.1 | 8.3 | | |

Where two figures are given above the first applies to small insulators, and the second to the largest with fairly uniform steps between, except where noted as erratic.

When subjected to artificial fog the salt-coated insulators showed in most cases a decided decline in flashover voltage; the flashover voltage of dirt-coated insulators under fog conditions also was decreased but not so severely.

In a further effort to study the effect of surface conditions on the flashover of insulators, other insulators were hung on the roof of the laboratory for a period of one year, each insulator being flashed over approximately once a month. Since the laboratory is situated in a heavy industrial district the insulators were subjected to soft coal smoke and industrial gas fumes. All flashover measurements were made at a time when the insulators apparently were thoroughly dry. These tests were made, of course, at such humidity and temperature as happened to exist at the time. Results are plotted in Fig. 11. It may be noted that the curves are identical with those of Figs. 9 and 10.

Certain points on each of the curves of Fig. 11 fall materially below the average. The low values did not occur toward the end of the exposure period as would be expected if they were due to an increase in dirt accumulation with time. In fact the reading taken at the end of the year lies on the curve very nicely at 0.659 in. of mercury vapor pressure. The group of low values recorded at 0.235 in. vapor pressure occurred after the third month of exposure. The low values shown at 0.292 and 0.314 in. vapor pressure occurred, respectively, after seven months and two months. It is believed that in these cases the dirt film on the surface was slightly moistened. Since most of the tests were made in the morning it is quite possible that in these cases there was still a small amount of invisible dew remaining on the surface of the insulators.

Agreement between the curves in Figs. 9 and 10 and those in Fig. 11 is interesting especially in view of the temperature variation in the latter tests. The highest temperature recorded during the time of exposure was 82 deg. fahr., occurring at the time of the first observation after zero time of exposure; the lowest temperature recorded was 27 deg. fahr., occurring at the test after the fourth month of exposure.

## CONCLUSIONS

Relations found between arcing distance and insulator flashover and between humidity and insulator flashover are indicated in the foregoing curves and have been summarized in Table II;

the following conclusions seem justified:

1. At high relative humidities there is in some cases a scattering of test results with points falling below the humidity curves. This is believed to be due to the precipitation of a fine moisture film on the surface of the insulators.
2. Deviation of individual flashover voltages from the average are not fully explained by humidity variations alone. After correction for humidity has been made, a variation of about plus or minus 5 per cent remains in some cases.
3. The same humidity corrections are applicable to dry, dirty insulators as to clean insulators.
4. Dry dirt on the insulator surfaces only slightly lowers the flashover voltage, but a small amount of moisture greatly reduces the flashover voltages of dirty insulators, particularly if the dirt is of a saline nature.
5. At high relative humidities the flashover voltages of salt-coated insulators is materially reduced due to absorption of water by the salt.

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# II—Factors Affecting Insulator Sparkover

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WHILE the mechanical properties and strength of the various parts entering into the design of a modern transmission system are quite well known, the electrical characteristics of the various parts often are not so definitely understood. This is true particularly of the electrical properties of the insulating parts, including the line and station insulation and bushings used in the station equipment. In this article are presented data on the sparkover strength of the various parts used for the insulation of modern high voltage transmission systems. Results are given of tests made to determine how insulator sparkover is affected by various factors.

The more common factors having a direct influence on the sparkover voltage of insulators are: temperature, barometric pressure, humidity, smoke, steam, dew, fog, rain, and surface dirt and moisture. Effects of temperature and barometric pressure on the 60-cycle sparkover voltage were determined some years ago. On the basis of these earlier studies it is generally sufficiently accurate to assume that the change in sparkover voltage is directly proportional to the change in air density; this holds true for both 60-cycle and lightning or impulse voltages. All sparkover voltages in these tests have been corrected to an air density of unity, using correction factors determined in the earlier tests.[1,2]

Regarding the effects of humidity but little data heretofore have been published.[3,4] Tests made in different laboratories, under identical conditions in so far as A.I.E.E. specifications are concerned, often fail to produce identical results. For the most part these differences can be attributed to the effect of humidity or water vapor in the atmosphere in which the tests are made. Effects of some of the remaining factors enumerated in the preceding paragraph have been recognized for some time but in most cases specific quantitative data have been lacking. Accordingly, some heretofore unpublished data on the effects of these factors are presented in this article.

## HUMIDITY

When the humidity for a given sparkover test has been specified, common practise has been to express it in terms of relative humidity. No confusion would result by such a procedure if all sparkover tests were made at approximately the same temperature. The effect of humidity then would be indicated by plotting sparkover voltage as a function of relative humidity. Sparkover tests, however, sometimes are made over a wide range of temperature, but the results so plotted are of little value in comparing the humidity effect and in finding an agreement in the sparkover voltage at some given humidity. A single curve of sparkover voltage as a function of relative humidity for different temperature cannot be drawn; the effect can be shown only by drawing a group or family of curves, each individual curve pertaining to one particular temperature.

Since humidity generally has been expressed in relative values, it has been difficult to interpret its true effect; hence different laboratories have found it hard to agree upon the sparkover voltage at any given humidity. When reduced to an absolute-humidity basis, however, the tests made by different laboratories show strikingly similar results; this is revealed by the curves shown in Fig. 12. These tests have been made with four different sets of testing equipment in four laboratories. Three of the laboratories employed artificial humidity control; the fourth was an outdoor laboratory in Pittsfield, Mass., under natural humidity conditions occurring from day to day and season to season. All these tests were conducted in accordance with A.I.E.E. Standard No. 41. The dip in these curves beyond a density of about 9 grains per cu. ft. will be discussed later.

Effects of humidity on the sparkover voltage of standard-duty suspension insulators of different sizes and having different spacings are shown in Figs. 12, 13, and 14; Fig. 15 shows the effect of humidity on certain sizes of pedestal insulators and a large pin insulator.

The sphere-gap appears to be practically independent of humidity effects. This is not true of the needle-gap, however, as may be seen from Fig. 16. These data are in agreement with previous data on the effect of humidity on the sparkover of spheres and needles.[4,5] In Fig. 17 the data of Fig. 16 are rearranged to show sparkover voltage as a function of gap spacing; the standard needle-gap curve also is indicated.

It may be noted that several of the humidity-sparkover curves for insulators indicate a lowering of

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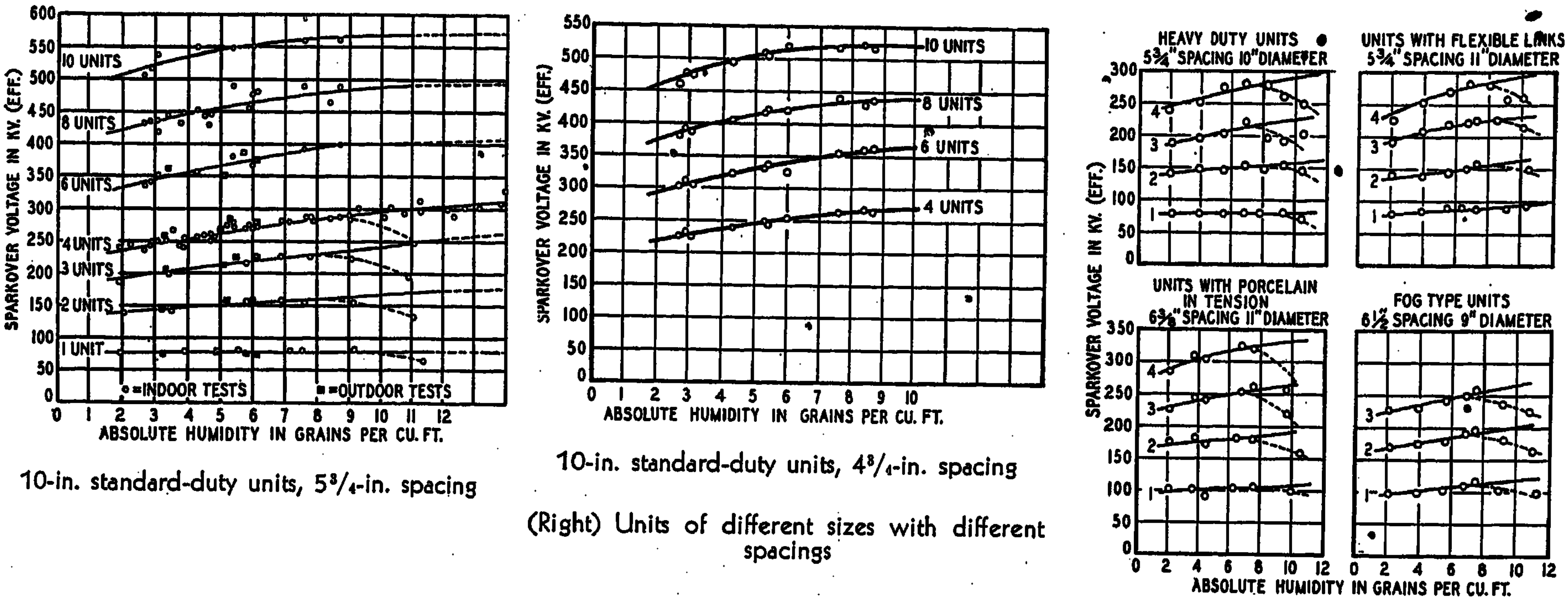
Based upon "Insulator Sparkover—Factors Affecting the Sparkover Voltage of Insulators Used on High Voltage Transmission Systems" (No. 32-59) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932.

the voltage sparkover for absolute humidities above approximately 9 or 10 grains per cu. ft. That this is an effect of surface moisture or condensation on the porcelain surfaces of water vapor from the atmosphere at these high absolute (and generally relative) humidities, and not an effect in the air-gap, is indicated by the absence of this effect in the curves for the needle-gap and sphere-gap, particularly the



10-in. standard-duty units, 5¾-in. spacing

10-in. standard-duty units, 4¾-in. spacing

(Right) Units of different sizes with different spacings

**Figs. 12, 13, and 14. Effect of humidity on the 60-cycle sparkover of suspension insulators**

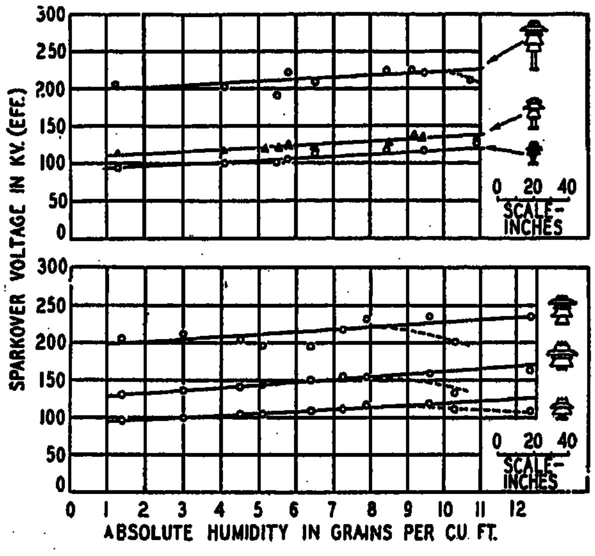
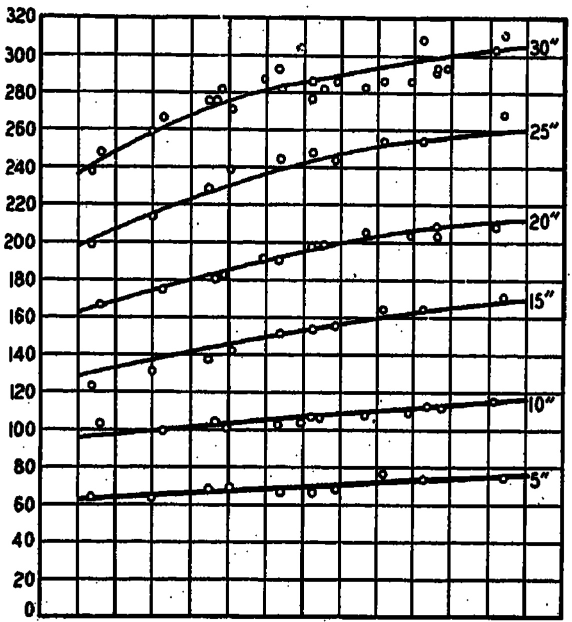
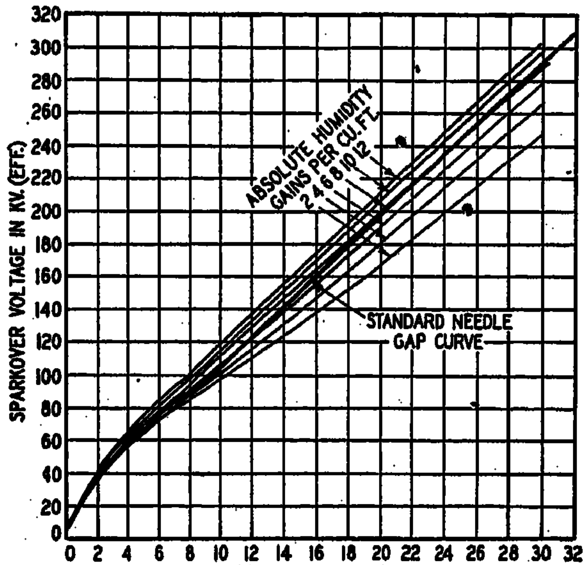


**Fig. 15. Effect of humidity on the 60-cycle sparkover of pin and pedestal insulators**





**Figs. 16 (left) and 17 (above). Effect of humidity on the 60-cycle sparkover of the needle-gap**

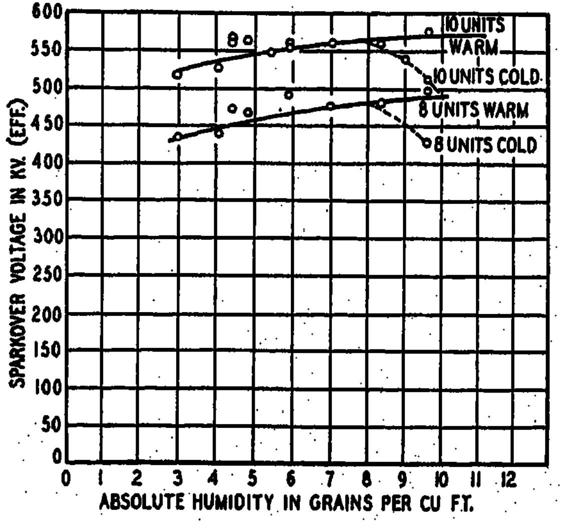


**Fig. 18. Effect of humidity on the 60-cycle sparkover of suspension insulators showing influence of condensed moisture on surface of insulators at high humidity**

10-in. standard-duty units, 5¾-in. spacing

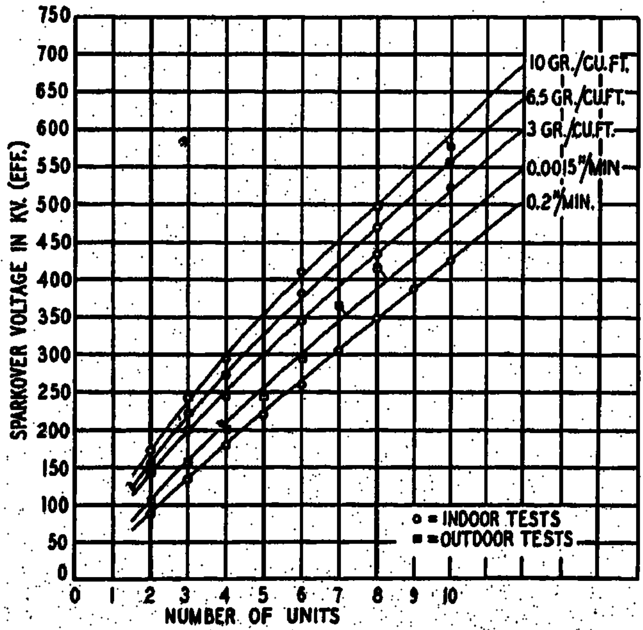


**Fig. 19. Effect of rain on the 60-cycle sparkover of suspension insulators**

10-in. standard-duty units, 5¾-in. spacing

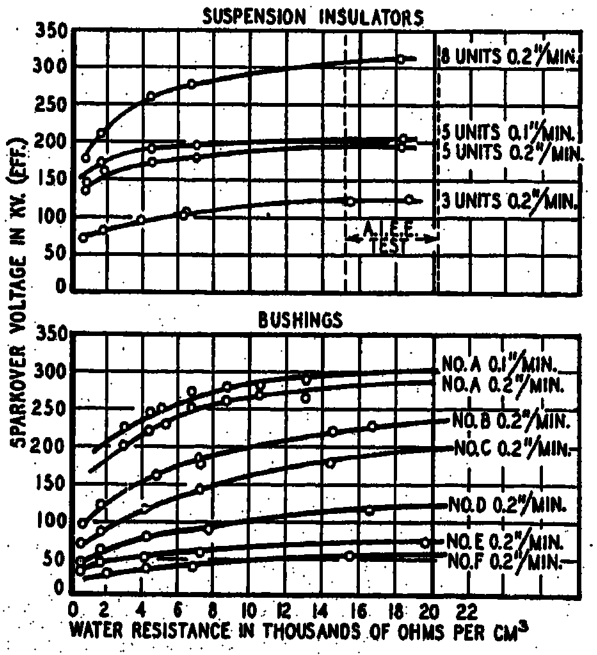


**Fig. 20. Effect of water resistance on the wet sparkover of suspension insulators and bushings at 60 cycles**

former. This conclusion is indicated also by the data in Fig. 18 where tests were made on chilled and slightly heated insulators. It is indicated also by the difficulty commonly experienced when tests on insulators at high humidities show a constantly rising sparkover voltage in repeated tests. The surface moisture results in low sparkover voltage in the initial test; repeated sparkovers remove this surface moisture and the insulator gradually acquires the higher sparkover voltage resulting from the high humidity. Frequently this increase continues for 25 or more tests before the sparkover voltage becomes constant at the upper value.

## SMOKE, ATMOSPHERIC MOISTURE, AND SURFACE DIRT AND MOISTURE

In this portion of the investigation 60-cycle sparkover tests were made on 10-in. standard duty suspension insulators with $5^3/_4$-in. spacing in atmospheres of smoke, steam, dew, fog, rain, and on insulators coated with surface dirt and moisture. Results of these tests are shown in Figs. 19, 20, and 21.

Results of tests made under dry, light rain, and heavy rain conditions are shown in Fig. 19; these are for insulators in a vertical position. Rain tests with the insulators in a horizontal position indicate no lowering of the sparkover potentials with the rain directed either at right angles to the string, or either from or toward the line end at an angle of 45 deg. to the string, and at 45 deg. from the vertical in all cases. On a horizontal string, rain improves the voltage distribution along the string sufficiently to raise the rain sparkover potentials to that of the dry. In the vertical position the drip along the vertical axis overbalances this effect and actually lowers the sparkover potentials. In Fig. 20 are shown the variations of sparkover voltage with resistivity of the water and rate of precipitation for clean insulators and bushings.

The effects of dirt and moisture on the 60-cycle sparkover are shown in Fig. 21. For these tests the insulators were exposed for a long time to the steam and smoke from a locomotive until they were coated with a carbon deposit perhaps $^1/_{32}$ to $^1/_{16}$ in. in thickness. From Fig. 21 the following observations may be made.

1. When dry the deposited dirt had practically no effect upon the insulator sparkover.
2. Sparkover potentials for the dirty insulators with top surface moistened were but slightly lower than for clean insulators with top and bottom surfaces moistened.
3. Clean and dirty insulators had approximately the same sparkover potentials under artificial rain conditions of 0.2 in. per min. at 45 deg. from vertical, as specified by A.I.E.E. tests. This was presumably because some washing of the insulators took place.
4. Dirty insulators with both top and bottom surfaces moistened (by light spraying) had low sparkover voltages.
5. Under conditions just indicated in item 4, combined with an atmosphere of heavy steam and locomotive smoke surrounding the string, the sparkover voltages were the lowest of any measured in these tests.

## LIGHTNING SPARKOVER

Results of tests to determine the effect of humidity upon lightning sparkover of different insulators are given in Fig. 22. It may be noted that the variation in sparkover potential between a density of 3 and 10 grains per cu. ft. was found to be approximately plus and minus 10 per cent for the sizes tested. This is of the same order as with 60-cycle voltages. Similar tests made on various gaps show corresponding results. Dew, fog, rain, and surface moisture were found to have but little effect upon the lightning sparkover of insulators, but in general their effect decreases as the length of the wave decreases.

Tests on wood poles and crossarms, with and without porcelain insulators mounted on the arms, exhibit lightning sparkover characteristics similar to those of porcelain insulators alone. Wood poles, crossarms, and guy insulator sticks of different cross-sectional areas have a lightning sparkover potential of approximately 175 kv. per ft. of length, whether the wood be dry or wet with clean water or saturated with salt water and brine.[6] The probable reason for this is that water is a fairly good insulator for impulse voltages as compared with air in which these materials ordinarily are tested.

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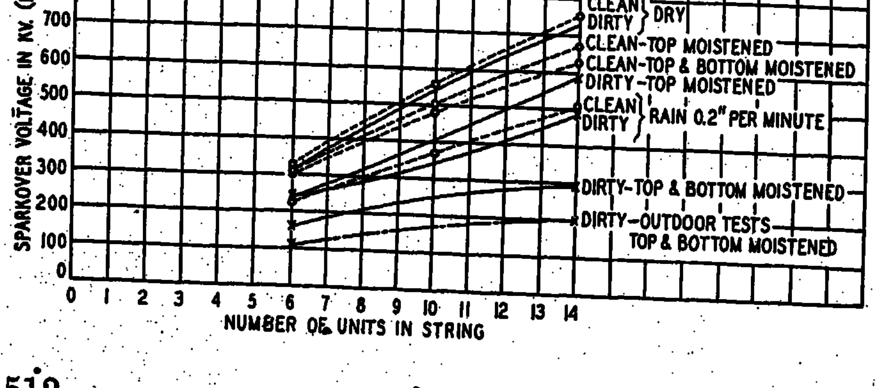

**Fig. 21. (Left) Effect of surface moisture and dirt on the 60-cycle sparkover voltage of suspension insulators; 10-in. units with $5^3/_4$-in. spacing**

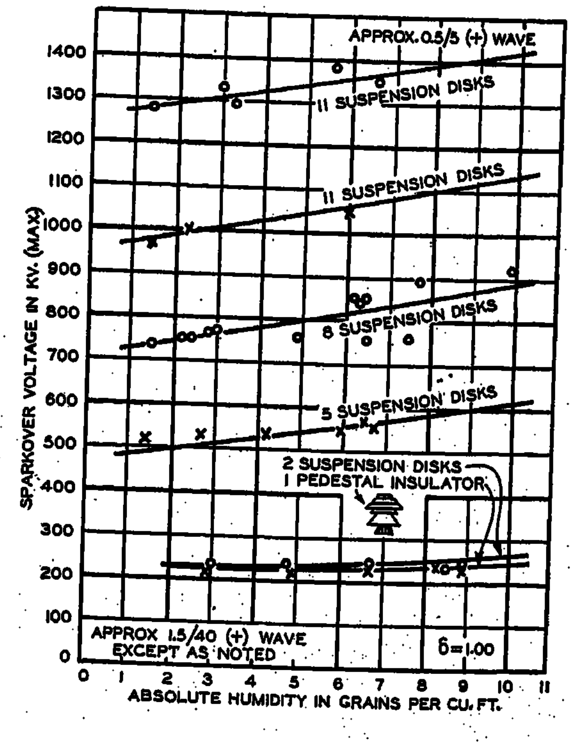

**Fig. 22. (Right) Effect of humidity on the lightning sparkover of insulators**

# III—Designs and Economics of Suspension Insulator Strings

By
J. J. TOROK
ASSOCIATE A.I.E.E.

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IN THE PAST the effectiveness of transmission line insulation has been judged almost entirely by its 60-cycle flashover characteristics. On this basis the wide changes in spacing and diameter of suspension insulator units have affected the over-all flashover values but little. Recently, however, it has been realized that the criterion for insulation should be based upon impulse flashover characteristics rather than upon the 60-cycle behavior. Limited laboratory tests using impulse voltages showed that the impulse flashover voltage of insulator strings is changed appreciably by varying the diameter and spacing of the individual units. Economic studies show that, in general, low cost is associated with large diameter units spaced close together.

In a paper presented by Messrs. Fortescue and Conwell, and a discussion of that paper ("Lightning Discharges and Line Protective Measures," by C. L. Fortescue and R. N. Conwell, A.I.E.E. TRANS., v. 50, 1931, p. 1090–1100; discussion p. 1147) it was shown that on a transmission line equipped with ground wires, the reflections from tower footings altered the wave form so that the resultant voltage across the insulators had the approximate shape of the wave shown in Fig. 23. If the insulators are to be subjected chiefly to this type of wave, it is essential to determine how the insulators will perform under such waves.

To be comprehensive, an investigation of the characteristics of insulators should be made on a volt-time basis; that is, waves of long duration should be applied to the insulators, and the voltage varied so that flashover will take place in time lags ranging from sixteen or more microseconds down to one or two. The performance of the insulation then should be judged according to its application: If it is to be used on lines equipped with ground wires, the performance of the insulation should be judged by the flashover voltage at short periods of time; if it is to be used on lines not equipped with ground wires, its performance should be judged by long time lags as well as short. However, the majority of the transmission lines now being planned and constructed are to be equipped with ground wires. Therefore, the emphasis of this analysis will be placed on short time flashovers.

## TESTS ESTABLISHING A COMPARISON BASIS

Laboratory tests were made on suspension insulator assemblies and on bushings with the voltage wave shown by the oscillogram of Fig. 24. This voltage wave closely resembles the calculated curve shown in Fig. 23. The principal object of these tests was to determine the relation between flashovers with this type of wave and those given by standard volt-time curves.

The following crest voltages are the minimum values causing flashover of insulator assemblies made up of 10-in. units spaced $5^3/_4$ in. apart, when subjected to this type voltage wave:

| No. Units | Crest Voltage (kv.) |
|---|---|
| 8 | 1,050 |
| 10 | 1,240 |
| 12 | 1,550 |
| 14 | 1,800 |

From the volt-time curves shown in Fig. 25 it can be seen that these voltages correspond to flashovers at some time lag between 1 and 2 microsec. on $1^1/_2$–40 positive-wave volt-time curves. (A $1^1/_2$–40 wave is one in which the time from zero to crest is $1^1/_2$ microsec. and the time from to crest to half voltage on the tail of the wave is 40 microsec.) The minimum flashover voltage decreases and corresponds to longer time lags when longer-duration test waves are used. It has been shown previously that longer waves than that shown in Fig. 23 may be expected on lines having high tower footing resistances, and that effective ground wire protection can be had only with tower footing resistances less than 10 ohms. With higher tower footing resistances voltages appearing across the insulators become so high that it is uneconomical to insulate against strokes of even moderate intensity. For these reasons, the comparison of insulators for use on lines properly equipped with ground wires should be made at 2 microsec. as taken from volt-time curves.

Special field conditions may require a different wave upon which to base analyses; consequently, provisions were made for varying the magnitude of the $1^1/_2$–40 microsec. positive wave used in these tests, so as to give time lags of flashover ranging from 1 to 20 microsec. The results then were plotted in the form of volt-time curves from which insulator performance can be ascertained for any predetermined wave shape. In the event that some peculiar local condition necessitates the choice of an irregular wave as a basis of test, it is necessary to test only one combination of insulators with this wave. The flashover voltage values then may be referred to the volt-time curve to ascertain the corresponding time lag. The comparison of various types of insulators can be made at the corresponding time lag from their respective volt-time curves.

If the high voltage transmission line is not protected by ground wires, or if the ground wire protection is inadequate, then the voltage wave form across the insulators is not accompanied by reflections from tower footings; therefore the wave shape approximates that of the lightning discharge. The

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Based upon "Suspension Insulator Assemblies, Their Design and Economic Selection" (No. 32-61) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932.

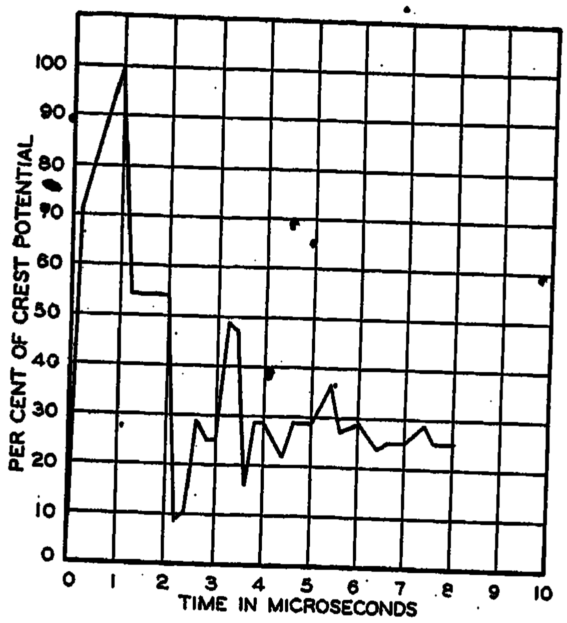


Fig. 23. Calculated wave shape of voltage impulse on a transmission line equipped with ground wires

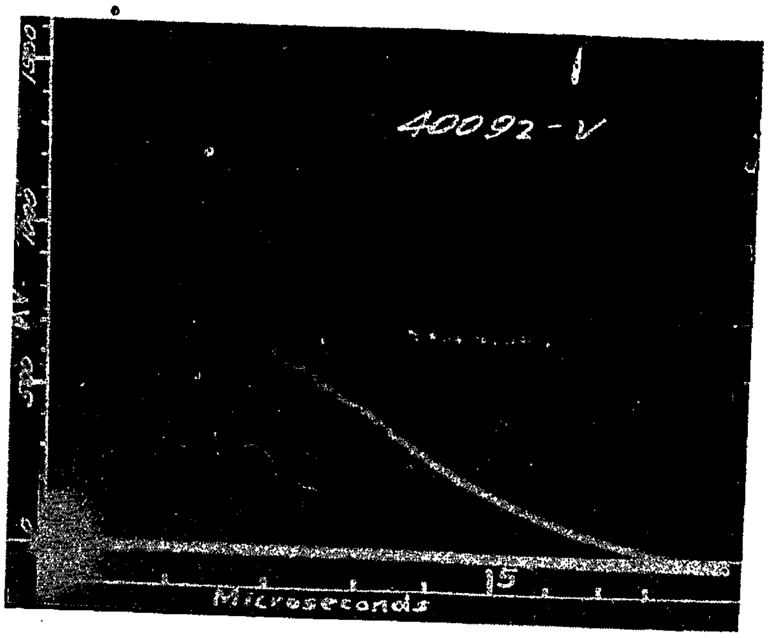


Fig. 24. Oscillogram of voltage impulse used for the tests described in this article

wave form in this case is of longer duration, ranging from 10 to 50 microsec.

## Diameter and Spacing Tests

To determine the relation between insulator dimensions and flashover characteristics of suspension insulator assemblies, a series of tests was conducted for which insulators of the cemented cap and pin type were made in a variety of shell diameters and unit spacings. The porcelain shells were standard in head, petticoat, and shed droop design except for a special $10^1/_2$-in. diameter unit designed for coastal duty. This unit had 10 per cent greater shed droop than the standard design. Heads of all these units were the same size so that all hardware was identical; this head size was the same as that of a standard-strength unit now most commonly employed upon high voltage lines.

Shell diameters of the insulators tested were, respectively, 7, $8^1/_2$, 10, $10^1/_2$, 12, and 14 in. Unit spacings ranged from a minimum possible value to a maximum value considerably greater than any spacing that has been employed for line insulation. The specific spacings used in the tests were, respectively, $4^3/_4$, $5^3/_4$, $6^1/_2$, $7^1/_2$, and 10 in. These variations in spacing were obtained by pins of various lengths being screwed into a threaded socket provided on the stud. This arrangement materially reduced the number of units required for the tests and afforded more comparable data because identical shells of each diameter were tested at all spacings.

Conventional 60-cycle dry and wet flashover tests were performed on strings of 4, 8, 12, and 16 units of each dimension combination; that is, the units in each string assembly were all of the same diameter and spacing. No non-uniform string assemblies were tested because these conglomerations have been found to be impractical line assemblies. The tests were made in accordance with A.I.E.E. Standard No. 41 pertaining to the conduct of normal frequency flashover tests.

Impulse flashover tests were made on the same string assemblies with a $1^1/_2$–40 microsec. wave of positive polarity. A cathode ray oscillogram was made of each impulse flashover, over 700 such records being obtained. These data were corrected for variations in atmospheric temperature and density, but no correction was made for the recorded relative humidity which ranged between 10 and 15 per cent. Correction factors for humidity have not been established, but at present are under consideration by the A.I.E.E. lightning and insulator subcommittee. It is the authors' opinion that the variation in impulse flashover voltage caused by changes in humidity during these tests is negligible. This opinion is based upon wet and dry impulse flashover tests.

Some of the data obtained from the impulse tests on various insulators are given in the replotted curves shown in Fig. 25. These curves were obtained from time lag curves, each of which was plotted from an average of 13 points. Some combinations of unit dimensions were not tested under the impulse wave as the test would become too long. The omitted combinations were so selected that they could be readily interpolated from the other tests.

Units found to be most effective under impulse tests were subjected later to arc tests to check the behavior of these diameter shells under high current impulses and power follow arcs. An eight-unit string of 12-in. diameter shells was subjected to more than 100 severe impulse flashovers, in addition to the normal impulse flashover characteristic tests, at an approximate rate of voltage rise of 6,000 kv. per microsec., and a current of approximately 5,000 amperes. These same units then were subjected to 60-cycle arcs of approximately 3,000 amperes for a duration of 2 sec. Since the 10-in. unit is the most common in practical use, this was chosen as a reference for comparison with the 12-in. unit. In the impulse tests neither the 10-in. nor the 12-in. units failed either by puncture or breakage. In the 60-cycle arc tests the performance of the 12-in. unit was as good if not slightly better than the 10-in. unit. These results are substantiated by service data available. All tests reported in this paper were made without auxiliary electrodes, such as rings and horns. The effect of such devices already has been investigated ("Impulse Flashover of Insulators," by J. J. Torok and R. Ramberg, A.I.E.E. Trans., v. 48, 1929, p. 239–45).

## Cost Considerations

In the selection of high voltage transmission insulators, the designer is confronted by two major considerations: first, the permissible cost of line insulation; and second, the selection of the maximum insulation available for that cost. Once the permissible cost of insulation has been decided upon, the most economic suspension insulator unit can be selected from examination of insulation and cost characteristics similar to those shown in Figs. 26 and 27. In Fig. 26 is shown the impulse flashover characteristics with respect to string length, of various assemblies of 10-in. and 12-in. diameter shells. These flashover voltages were taken at a 2-microsec. time lag for reasons advanced previously. It may be noted that for a given unit spacing and flashover voltage strings comprised of 12-in. shells are appreciably shorter.

In both Figs. 26 and 27, string length was chosen as the basis of reference, as it is a controlling factor in supporting structure dimensions. For a given flashover voltage, the shorter string length is more desirable on a tower cost basis, as it may reduce the length of the arm and height of the tower; or, with a given string length and the utilization of a more effective insulator, the flashover voltage will be increased and the number of outages due to lightning will be decreased. For example, in Fig. 26, a 1,500-kv. flashover at a 2-microsec. time lag is provided by a string length approximately 65 in. when composed of 12-in. units spaced $4^3/_4$ in., and by a string length approximately 91 in. when composed of 10-in. units spaced $6^1/_2$ in. A difference of 26 in. exists between the lengths of these strings. A steel tower design for use with the longer string of course would be appreciably heavier and more expensive than a tower with the same clearances and line height designed for the shorter string. Using 12-in. units spaced $4^3/_4$ in., a string length of 91 in. would have a flashover of 2,050 kv. as against 1,500 kv. for a string of the same length using 10-in. units spaced $6^1/_2$ in. apart. This means that an increase in flashover potential of 550 kv. is obtained by using the more efficient combination of diameter and spacing. These factors should exert considerable influence upon the choice of properly dimensioned suspension units.

### ECONOMIC SELECTION

To provide economic comparison curves the 2 microsec. time lag flashover characteristics of Fig. 26 were incorporated with the cost of the units to give the curves shown in Fig. 27. Cost values employed were those for a purchaser with packing and shipping expenses allowed to a shipping point 500 miles from the factory, and are based upon the physical dimensions of the units. Up to approximately 70-in. string length, a 12-in. unit spaced $6^1/_2$ in. provides insulation at the least insulator cost. This point corresponds roughly to the insulation considered as economically balanced for 138-kv. transmission on steel towers adequately protected by ground wires.

Beyond a string length of 70 in., a 12-in. unit

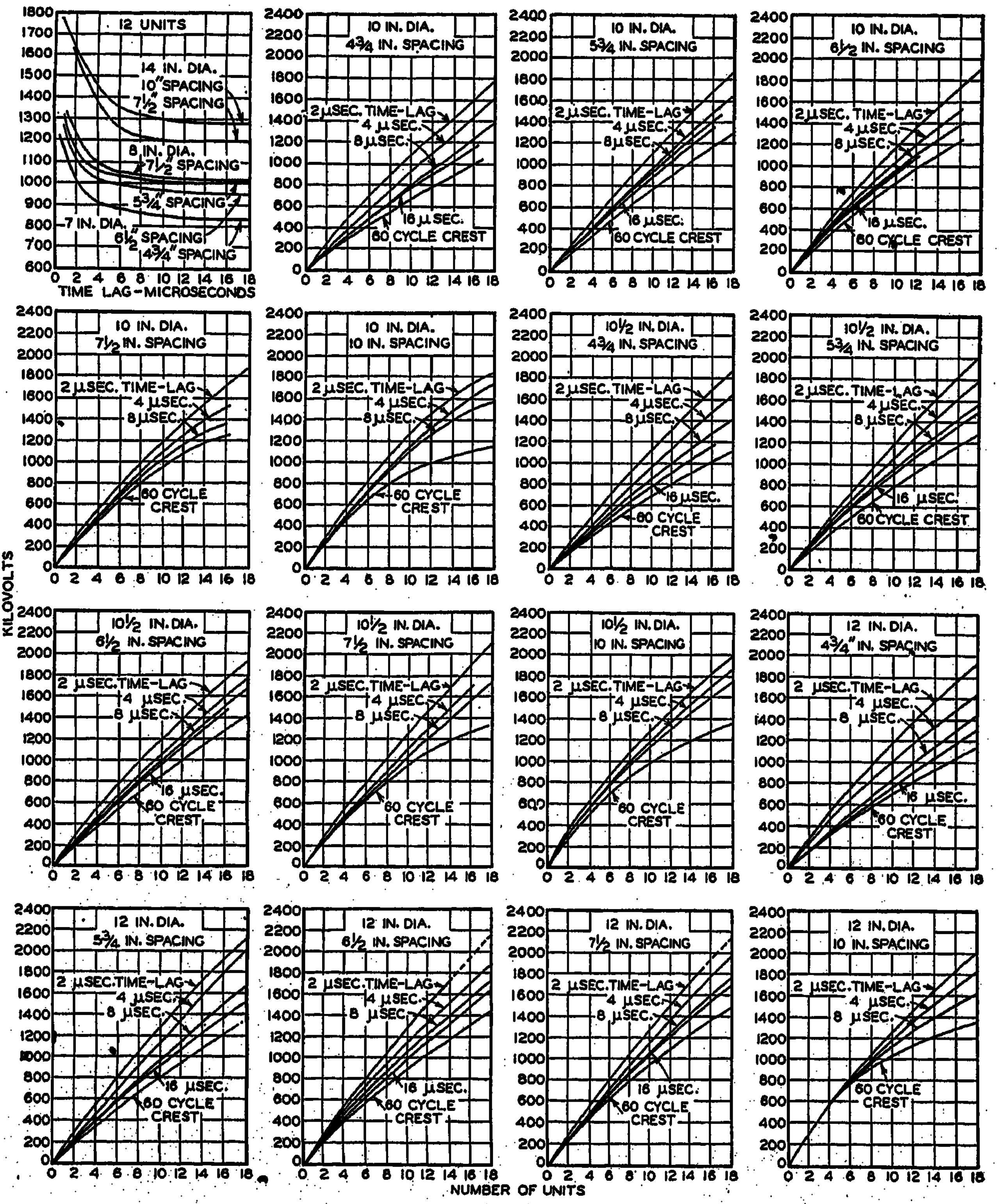


**Fig. 25. Flashover characteristics of suspension insulators**

All vertical scales show minimum flashover potential in kv.; horizontal scales (except upper left) show number of insulator units in the string spaced $5^{3}/_{4}$ in. shows the lowest insulation cost. Units 10 in. in diameter spaced $4^{3}/_{4}$ or $5^{3}/_{4}$ in. are the dimension combinations most commonly used at the present time for those string lengths. However, these units show much higher relative costs than 12-in. diameter units at the same spacing for string lengths of more than 30 in. Incidentally, a string length of 30 in. corresponds roughly to economically balanced insulation commonly employed for 69 kv.

Further examination of these flashover and cost curves clearly indicates a wide range of selection in the choice of the proper insulation. It should be noted, however, that to determine the maximum insulation for the least cost, Figs. 26 and 27 must be employed simultaneously. For example, at approximately 65-in. string length, 12-in. units spaced $5^{3}/_{4}$ in. provide a 1,500 kv. flashover rating at a relative cost of 1.76 or an arbitrary total cost of 2,640; whereas 10-in. units spaced $6^{1}/_{2}$ in. must have a string length of approximately 91 in. to provide the same flashover rating. This gives an arbitrary total cost of 1.93 times 1,500 which is 2,900 or approximately 10 per cent higher in cost with a 32 per cent increase in string length.

Low-cost units have been proposed for light duty, such as on wood construction and lower voltage transmission lines. Economic characteristics of such a unit are shown by the 9-in. diameter, 5-in. spacing curve of Fig. 27. Obviously, for light duty service requiring insulation corresponding to 60-in. string length (approximately 138 kv.) such units are desirable economically. For example, assume a 40-in. string of 9-in. units spaced 5 in. apart; from Fig. 26 this combination gives a flashover potential of 875 kv. at 2 microsec. time lag at the relative cost (Fig. 12) of 1.35 per kv. An equivalent string of 12-in. units, spaced $5^{3}/_{4}$ in. must have a length of approximately 40 in.; its relative cost is 1.7. Thus for the same electrical characteristics, the small unit shows a 20 per cent saving in cost. The economy of this smaller unit is the result of reduction in head size and consequently lower mechanical strength.

In wood pole construction, present practise is to use just sufficient porcelain to insulate the line for the normal operating voltage, and to depend upon the wood for impulse insulation. The insulator to be used for this type of service should have a low cost per kv. of 60-cycle flashover potential and mechanical strength slightly above that of the wood structure. Calculations of ultimate strengths of wooden structures now in use show that a unit having a mechanical strength of 7,000 lb. would be adequate.

## Conclusions

Principal findings of this study may be summarized as follows:

1. Two major factors in the design of steel tower transmission lines are (1) the shielding of the power conductors with properly located ground wires, and (2) maintaining the tower footing resistances as low as possible.

2. For towers of low footing resistance (on the order of 20 ohms) the wave is of short duration so that the minimum flashover voltage of the attached insulation corresponds to its breakdown voltage at 2 microsec. with a flat-topped wave.

3. In applying insulation to well protected high voltage lines, suspension insulators should be judged on the basis of their impulse flashover characteristics at 2 microsec.

4. Choice of insulation for lines either not protected or inadequately protected by ground wires is based upon impulse flashover values at long time lags, of the order of from 10 to 50 microsec.

5. Impulse flashover space effectiveness of suspension insulators improves with an increase in unit shell diameter at moderate spacings.

6. Impulse flashover space effectiveness for all unit diameters falls off with increase in unit spacing.

7. Flashover space effectiveness decreases with increase in string length.

8. Insulation cost for a given impulse flashover voltage generally is lower for larger diameter units and higher for larger unit spacings.

9. Available service data and laboratory tests show that a 12-in. unit is as serviceable as a 10-in. unit.

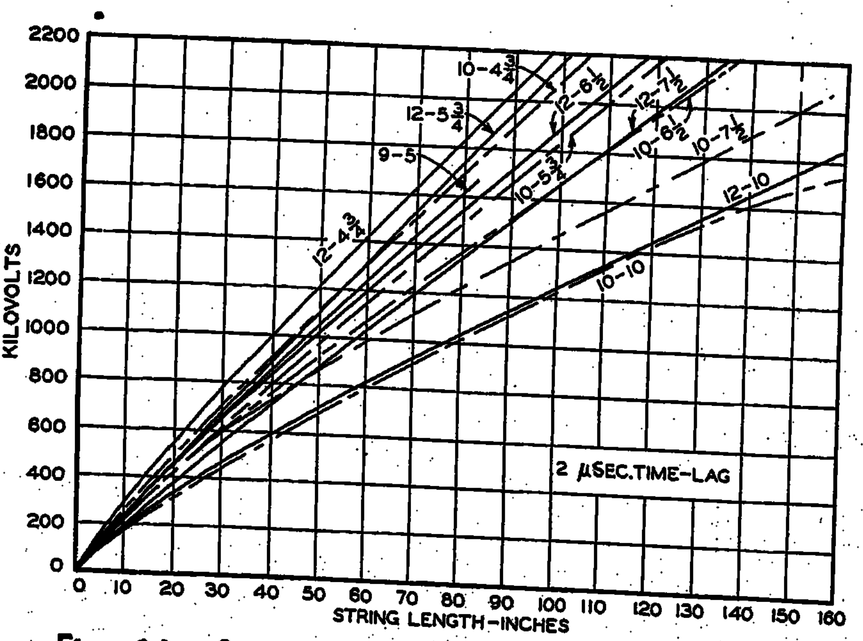


**Fig. 26. Suspension insulator flashover characteristics as a function of string length**

Numerals associated with the various curves indicate, respectively, the diameter of the individual units and the spacing between, both in inches

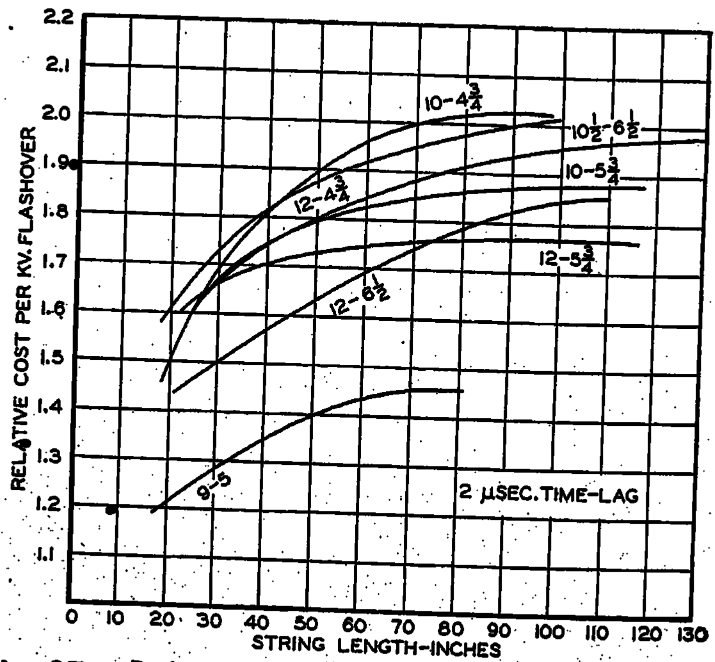
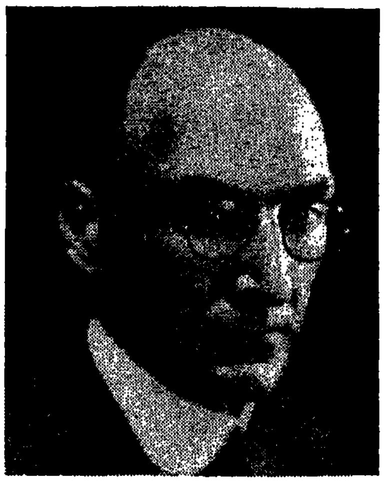


**Fig. 27. Relative costs of suspension insulator strings**

Numerals associated with the various curves indicate, respectively, the diameter of the individual units and the spacing between, both in inches

# Introducing the Newly Elected Group of the Institute's National Officers



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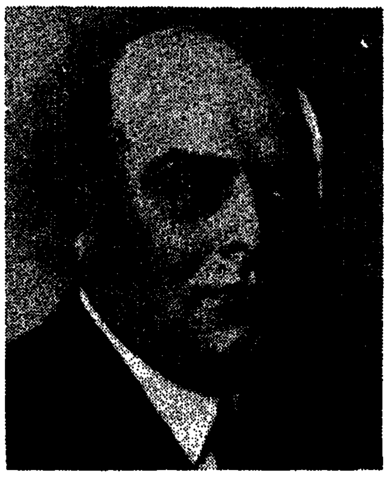

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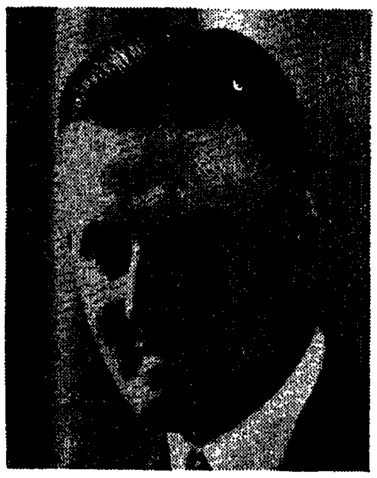

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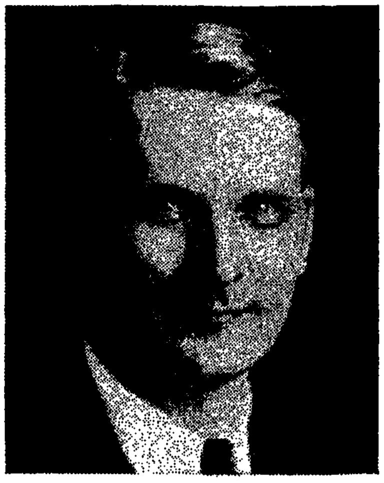

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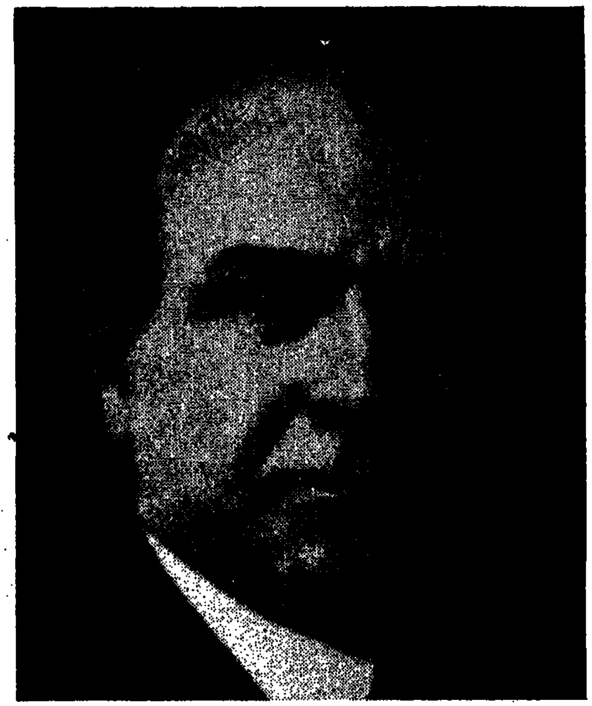

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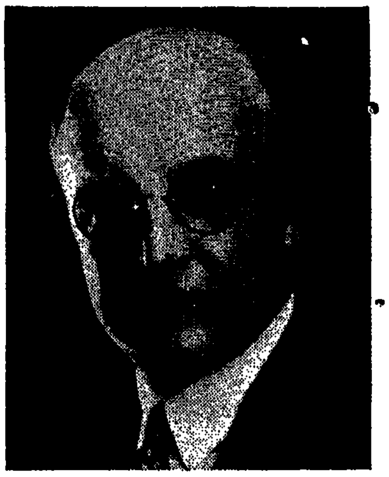

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# News
## Of Institute and Related Activities

# Pacific Coast Convention Program Announced

TECHNICAL and entertainment programs have been arranged for the Institute's Pacific Coast convention to be held at Vancouver, B. C., August 30 to September 2, 1932 and promise 4 days which should be truly inspirational to members and guests. In addition to the formal program there are excellent facilities for all types of sports and entertainment for those intending to spend their vacation in Vancouver.

### TECHNICAL SESSIONS

Fourteen papers offer a variety of subject matter embracing both theory and recent practise in the electrical engineering field. These will be presented in 4 sessions, one each on the following: power generation; transportation, electrical machinery and metering; transmission and communication; and station apparatus. Those interested in power system developments and the segregation of hydroelectric power costs should find the first session of particular interest to them. The second and fourth sessions should appeal to those who are theoretically inclined, as they contain valuable papers in the measurements field, such as metering of symmetrical components and high accuracy bushing current transformers. Other subjects—circuit breakers, factory assemblies for substations, and the theory of the 3-wire d-c. generator with 2-wire static balancer—lend variety to these sessions. The third session should prove to be of general interest as it contains several papers in the power transmission field which are theoretical and several others describing large radio systems, a subject of broad appeal. In addition, at one of these sessions there will be presented 2 papers on railway electrification which are of popular interest.

### ENTERTAINMENT FEATURES

On the evening of the opening day, Tuesday, August 30, the president's reception will be held in the Hotel Vancouver. Following the reception, there will be a dance in the Oval Room, dress being optional.

The boat trip on the second day, August 31, will consist of a 4-hr. cruise on the S. S. "Princess Norah" around Vancouver harbor and the surrounding coast. The harbor is some 2 miles long and is set amid truly wonderful mountain scenery. Dinner will be provided on the boat, also an orchestra, and arrangements are being made for dancing on the deck.

A golf tournament will be held on September 1 at the Shaugnessy Heights Golf Club. That evening a banquet will be held in the Oval Room of the Hotel Vancouver, followed by the presentation of golf prizes and a good program of entertainment.

At the luncheon to be held under the auspices of the Electric Club on September 2, the speaker will be Capt. E. A. Wheatley, registrar of the Association of Professional Engineers in British Columbia, and his subject will be "Engineering Legislation." Captain Wheatley is a pioneer in the movement to raise the status of the professional engineer to that of the doctor or lawyer. He is intensely enthusiastic and is remarkably well informed. It is felt that his address will be of vital interest to all.

On the afternoon of September 2, inspection trips will be made by groups in private cars, including a visit to the University of British Columbia, as well as to a number of other points of interest. During the same afternoon, a bridge tea will be held for the benefit of the women. For those attending the student conference, a dinner will be held that evening at Union College, University of British Columbia. This will be followed by a student conference.

### REGISTRATION

A fee for "banquet and entertainment tickets" will be payable at the time of registration. These tickets will cover the dance after the president's reception on August 30, the boat trip on August 31, and the dinner on the boat, the banquet on September 1, and in the case of the women, the bridge tea on September 2. The charges for these tickets will be as follows:

| | |
|---|---|
| Members and men guests | $7.50 per strip |
| Ladies | 6.00 per strip |
| Students | 2.50 per strip |

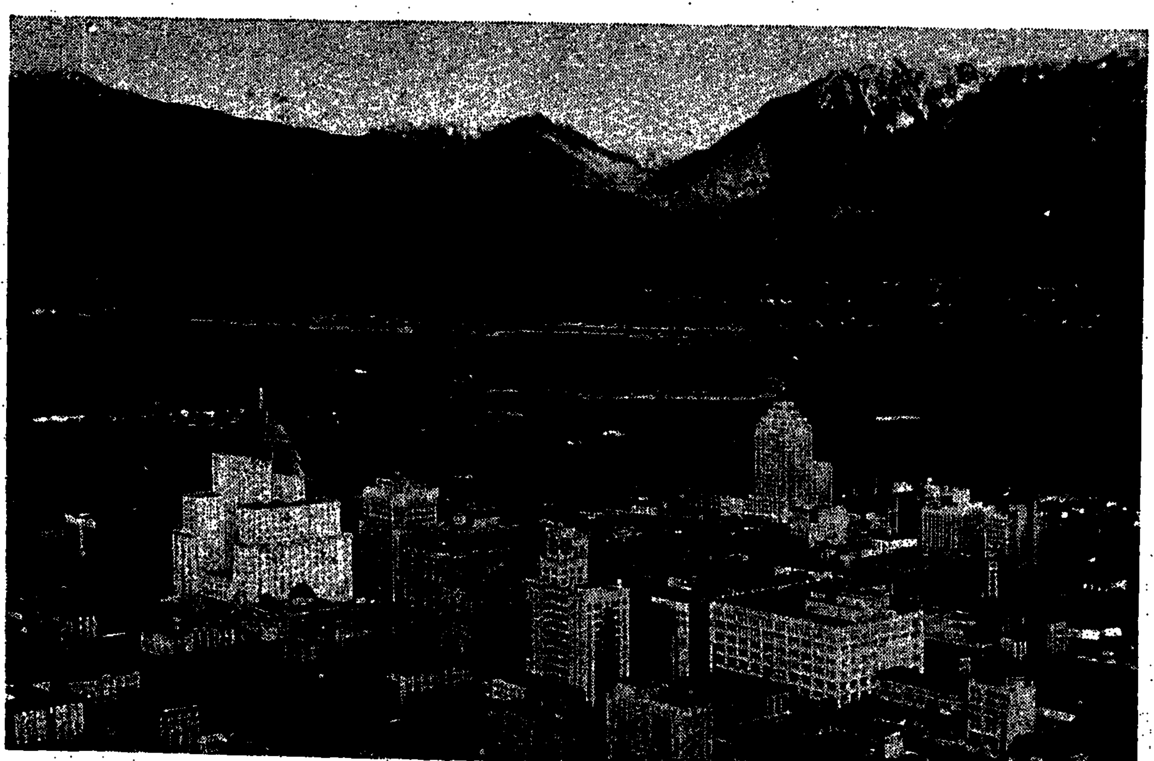
Tickets for individual functions will be sold only to students.

Rates which will prevail at the Hotel Vancouver, convention headquarters, are as follows:

| | |
|---|---|
| Double room, with bath | $6.00 |
| Single room, with bath | 4.00 |
| Double room, without bath | 5.00 |
| Single room, without bath | 3.00 |

The Terminal City Club, 837 West Hastings Street, Vancouver, will accommodate visiting students at $1 per day.

Regarding transportation, the annual summer excursion rates will be in force and therefore no steps have been taken to obtain special rates. Vancouver may be reached from practically any part of the Pacific states by road, rail, air, or water.



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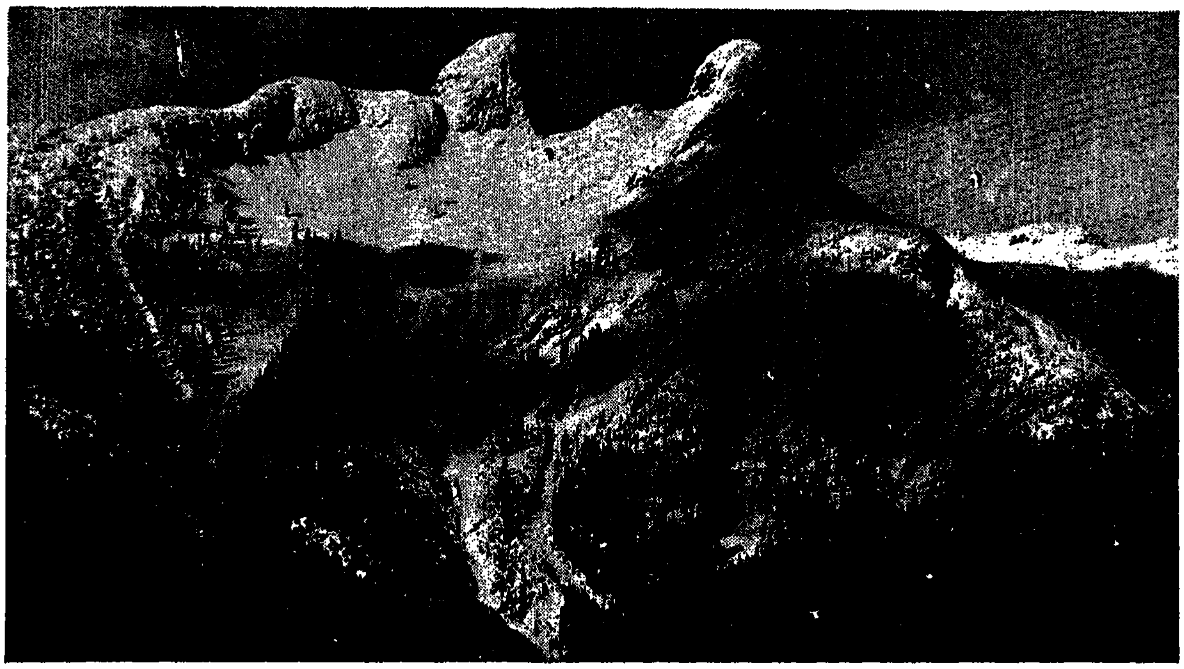
Aerial view of the business section of Vancouver, B. C., scene of this year's Pacific Coast convention of the Institute, August 30–September 2, 1932



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"The Lions," famous mountain peaks near Vancouver, B. C.

### Committees

General convention committees and officers serving in the various departmental divisions of convention activities are: *Chairman*, G. R. Wright (A'12) district manager, Canadian General Electric Company, Ltd., 1065 Pender Street, West, Vancouver, B. C.; *vice-chairman*, L. B. Chubbuck (M'26) switching equipment engineer, Canadian Westinghouse Company, Ltd., Hamilton, Ont., Canada; *secretary*, W. D. Robertson (A'27) central station engineer, Canadian General Electric Company, Ltd., Vancouver, B. C.; *treasurer*, C. Arnott (A'27) electrical draftsman, British Columbia Electric Railway Company, Ltd., 425 Carrall Street, Vancouver, B. C. Committee chairmen include: F. W. MacNeill (M'22) *entertainment;* J. R. Read ('04) *finance;* A. Vilstrup (M'27) *hotels and registration;* V. W. M. Fouracre (A'31) *publicity;* L. B. Stacey (M'29) *reception;* J. Teasdale (A'24) *technical program;* E. G. Cullwick (A'26) *student activities;* C. W. Colvin (M'21) *transportation;* D. de M. Mertens (M'25) *golf;* and Mrs. F. W. MacNeill, *ladies' entertainment*. These are assisted by P. S. Biegler (F'29), E. A. Crellin (F'28), M. T. Crawford (F'22), R. J. Davidson (A'21), J. H. Hamilton (A'28), Paul Ransom (M'31), L. E. Reukema (A'24), J. A. Thaler (F'13), H. Vickers (M'26), and H. L. Vincent (A'25), all members of the local committee.

## Program

All technical sessions and the opening of the convention will be held at the Hotel Vancouver. Abstracts of papers to be presented at the sessions are scheduled for publication in the August 1932 issue of Electrical Engineering.

### Tuesday, August 30

**9:30 a.m.—Registration**

**9:15 a.m.—Meeting of District Student Committees**

**10:00 a.m.—Opening of Convention by President H. P. Charlesworth**

**10:30 a.m.—Power Generation**

*The Power System of the British Columbia Power Corporation, Ltd., E. E. Carpenter, British Columbia Electric Railway Co.

*Rock Island Development of the Puget Sound Power & Light Co., A. P. Newberry, Puget Sound Power & Light Co.

*Segregation of Hydroelectric Power Costs, W. S. McCrea, Jr., Dept. of Public Works, State of Washington.

**12:00 m.—Luncheon, Students and Counselors**

**2:00 p.m.—Transportation, Electrical Machinery, and Metering**

Reading Company's Philadelphia Suburban Electrification, G. I. Wright, Reading Co.

*Electrical Operation on the Cascade Division of the Great Northern Railway, J. B. Cox, General Electric Co.

Theory of Three-Wire D-C. Generator With Two-Phase Static Balancer, E. G. Cullwick, University of British Columbia.

*Metering of Symmetrical Components, G. R. Shuck, University of Washington

**8:00 p.m.—President's Reception**

### Wednesday, August 31

**8:00 a.m.—First Student Session**

**12:00 m.—Luncheon, Institute District and Section Executives and Student Counselors**

**2:00 p.m.—Second Student Session**

**5:30 p.m.—Boat Trip**

### Thursday, September 1

**9:00 a.m.—Station Apparatus**

*Shaping of Magnetization Curves and Theory of the Zero Error Current Transformer, A. C. Schwager and V. A. Treat, Pacific Electric Mfg. Corp.

*Factory Assemblies for Substation Design, H. M. Hobbs, Westinghouse Elec. & Mfg. Co.

*Operating Experience With High Voltage Circuit Breakers, R. E. Rowley, Dept. of Water & Power, City of Los Angeles

**2:00 p.m.—Golf Tournament**

**7:30 p.m.—Banquet**

### Friday, September 2

**9:00 a.m.—Power Transmission and Communication**

*Corona Loss Measurements for the Design of Transmission Lines to Operate at Voltages Between 220 Kv. and 330 Kv., J. S. Carroll, Stanford University, and B. Cozzens, Dept. of Water & Power, City of Los Angeles

*The Triple Harmonic Circuit in Three-Phase Power Systems, T. H. Morgan, Worcester Polytechnic Institute, and C. A. Bairos and G. S. Kimball, Stanford University, Calif.

*The Radio Plant of the R. C. A. Communications, Inc., H. H. Beverage, C. W. Hansell, and H. O. Peterson, of R. C. A. Communications, Inc.

*Radio Links in the System of the British Columbia Telephone Co., C. H. McLean, British Columbia Telephone Co.

**12:15 p.m.—Electric Club Luncheon**

**2:00 p.m.—Inspection trips**

**2:00 p.m.—Ladies' Bridge Tea**

**6:45 p.m.—Dinner at Union College, University of B. C., for those attending the Student Conference**

**8:00 p.m.—Student Conference**

### Rules on Presenting and Discussing Papers

At the technical sessions papers will be presented in abstract, 10 minutes being allowed for each paper unless otherwise arranged, or the presiding officer meets with the authors preceding the session to arrange the order of presentation and allotment of time for papers and discussion.

Any member is free to discuss any paper when the meeting is thrown open for general discussion. Usually 5 minutes are allowed each discusser. When a member signifies a desire to discuss papers on other subjects or groups, he shall be permitted a 5-minute period for each subject or group.

It is preferable that a member who wishes to discuss a paper give his name beforehand to the presiding officer of the session at which the paper is to be presented. Copies of discussion prepared in advance should be left with the presiding officer. Each discusser is to step to the front of the room and announce, so that all may hear, his name and professional affiliations. Discussions at the technical sessions are not reported. To be considered for publication, discussions should be written and mailed to the A.I.E.E., Editorial Department, 33 West 39th Street, New York, N. Y., on or before Sept. 16, 1932.

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* These papers are under consideration for presentation at the Pacific Coast convention, but up to date of going to press have not been officially placed upon the program.

## Franklin Institute Honors Doctor Swasey

At this year's medal meeting of the Franklin Institute, May 18, 1932, Dr. Ambrose Swasey (HM'28) was awarded the Franklin Medal and certificate of honorary membership in the Franklin Institute. These are the highest honors bestowed by this organization, founded in 1824, the presentation taking place in the old hall of the Franklin Institute.

Doctor Swasey, who was honored as the inventor of a range-finding device which proved of great service during the World War, delivered an address, "Astronomers and Their Telescopes," upon this occasion. A banquet followed in the evening at the Bellevue-Stratford Hotel, at which Doctor Swasey and the recipients of other medals were guests of the Franklin Institute.

# Cleveland Convention A Pronounced Success

FROM Mexico City to Saskatchewan, from British Columbia to Florida, and even from England came members and their guests to attend the 48th annual summer convention of the Institute held at Cleveland, Ohio, June 20–24, 1932. A fitting tribute to the Cleveland convention committee, and an inspiring exemplification of the sturdy qualities of the Institute and its loyal members was the record of attendance, which was 1,022. From Cleveland and vicinity the total registration was 544, and from points other than Cleveland 478. Reflecting the attractive characteristics of the convention program of technical, social, and entertainment features, the attendance this year represents some 111 per cent of the average attendance of the last 10 summer conventions and 63 per cent of the maximum ever recorded at a summer convention (Swampscott, Mass., 1,616 in 1923), figures which compare far more than favorably with those of other similar national conventions held this season. Summer convention attendance for the past 10 years has been:

| | | |
|---|---|---|
| 1932 | Cleveland, Ohio . . . . . . . . . | 1,022 |
| 1931 | Asheville, N. C. . . . . . . . . | 525 |
| 1930 | Toronto, Ont., Canada . . . . . | 1,110 |
| 1929 | Swampscott, Mass. . . . . . . . | 1,000 |
| 1928 | Denver, Colo. . . . . . . . . | 500 |
| 1927 | Detroit, Mich. . . . . . . . . | 1,200 |
| 1926 | White Sulphur Spgs., W. Va. . . . | 350 |
| 1925 | Saratoga Spgs., N. Y. . . . . . . | 900 |
| 1924 | Chicago, Ill. . . . . . . . . . | 750 |
| 1923 | Swampscott, Mass. . . . . . . . | 1,616 |
| 1922 | Niagara Falls, N. Y. . . . . . . | 950 |

Particular credit is due the personnel of the Cleveland committees for the unqualified success of the convention and for the improvements in program brought about, through the adoption of some new features and the abandonment of some traditional activities. The many "little things" so often overlooked in the bustle of a convention were cared for in thoughtful detail.

### Annual Meeting

As the opening session of the convention, the annual business meeting was held in the Ball Room of the Hotel Cleveland, Monday morning, June 20. The minutes are given in this issue, p. 522. Presided over by President Skinner, the session proved to be of considerable interest to those having at heart the affairs of the electrical engineering profession. Following introductory remarks by President Skinner, Dr. W. E. Wickenden, president of Case School of Applied Science, Cleveland, extended to the guests a most hearty welcome to the city. His manner, humorous yet sincere, was most appropriate to the occasion.

Following the presentation by H. H. Henline, acting national secretary, of an abstract of the annual report of the board of Directors, President Skinner announced the results of the recent election of officers. (See p. 517.) In his response, President-Elect H. P. Charlesworth paid tribute to the men preceding him in the highest office of the Institute, and modestly stated his desire to live up to his new obligations.

W. H. Harrison then read the report announcing the winners of Institute prizes for papers given during 1931, after which President Skinner presented the prizes. Among those receiving awards, W. H. Harrison and R. N. Conwell were the only ones present to receive their prizes at the opening session.

Unfortunately, illness prevented the attendance at the meeting of Giuseppe Faccioli, winner of the Institute's Lamme Medal for 1931; also C. C. Chesney, who was to have given the tribute to Mr. Faccioli, was not present. However, C. H. Kline (Pittsfield, Mass.) read the statements of both men, and a deep impression was created on those in attendance by the sincerity of feelings expressed in their simple remarks. In Mr. Faccioli's acknowledgment of the award he stated that, largely for the benefit of the younger engineers who might be present, he wished to emphasize the fact that "it was a pleasure—not work—for me to do the things which have won for me the Lamme Medal."

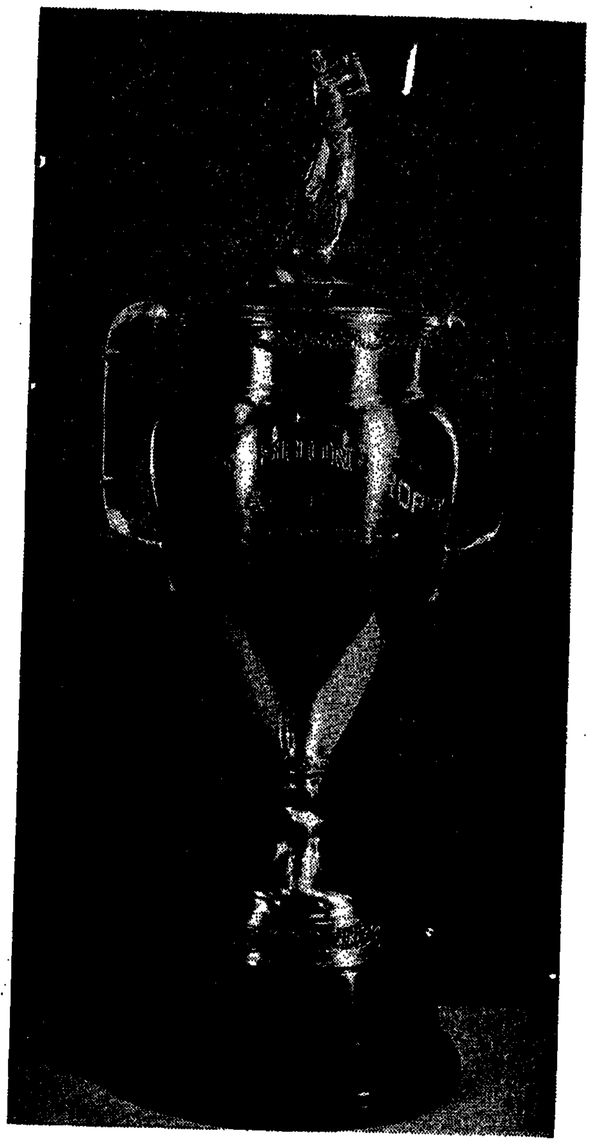
Doctor Skinner then delivered this year's presidential address, "The Institute and Its Members—Our Problems and Our Responsibilities." Printed in full in this issue of ELECTRICAL ENGINEERING, p. 472–6, its message is of direct concern to the membership of the Institute. Following the delivery of this address, the meeting was adjourned.

### Technical Sessions

Attendance at almost all of the technical sessions exceeded expectations, and in some cases exceeded arrangements which had been made for seating. The session on communication had an unusually general interest, and attracted many of the women guests. Other sessions, however, were more highly technical, and enabled the dissemination and discussion of much engineering information. At some of the meetings it was to be regretted that the lapel microphones used so successfully at previous Institute meetings were not employed. Abstracts of the summer convention papers were published in ELECTRICAL ENGINEERING for June 1932, p. 405–13, and will not be reviewed here. However, summaries of the discussions following presentation of some of these papers will be given in subsequent issues.

A special session for the entire membership was held on the morning of June 21, at which Dr. W. E. Wickenden delivered an address, "The Engineer in a Changing Society." This address, immediately recognized by those in attendance as being remarkable for its breadth of vision in analyzing the trends of society, especially as relating to the engineer, is published in this issue of ELECTRICAL ENGINEERING, p. 464–70. The increasing importance of the engineer in controlling the affairs of men was pointed out clearly, and encouragement given that greater social responsibility be accepted by the engineer.

Two afternoons were devoted to the conference of officers, delegates, and members usually held during the summer conventions under the auspices of the Sections committee and the committee on student Branches. A report of this conference is given in this issue, p. 522. A luncheon meeting of the board of directors of the Institute also was held, a résumé of this meeting being scheduled for a succeeding issue.



**The new Mershon silver golf trophy, for match play competition, stands 27 in. high above the base and is 12 in. in diameter**

### Trips and Entertainment

Cleveland's location made it particularly advantageous for the arranging of many attractive inspection trips, and all of these were very well attended. The outstanding trip, participated in by both members and guests, was the Akron-Barberton trip. This included a visit to the hangars of the Goodyear Zeppelin Corporation, and a tour of a rubber manufacturing plant attended by over 500, and dinner for 260 persons at the Mayflower Hotel, all in Akron, followed by a spectacular outdoor high voltage exhibition at the Barberton plant of the Ohio Brass Company. More than 800 witnessed this interesting demonstration. For the women, special trips and particularly appropriate entertainment features had been arranged for each day of the convention, and these proved to be very enjoyable. In the words of one woman guest, they were "priceless." The women's committee did a remarkably fine piece of work. At the Monday afternoon trip, 75 women were in attendance.

Evenings, too, were well utilized by both men and women. On Monday the president's reception and an informal dance were held; on Tuesday there was a boat trip on Lake Erie, in which 390 participated; on Wednesday the high voltage exhibition was staged at Barberton; and on Friday there were sight-seeing and other trips available.

The peak of the unusually attractive and popular social program was reached Thursday afternoon and evening when a variety of sports, a dinner, and an old-time party were arranged for every one at the beautiful grounds of Nela Park. These provided many hours of delightful relaxation for more than 500 participants. Ball games, golf, horseshoes, swimming, and tennis were among the sporting events during the afternoon, inspection trips being conducted simultaneously through the General Electric lighting institute. Following dinner and the presentation of awards to the winners of the various events scheduled during the week, including the golf and tennis trophies, a "regular old-time carnival" together with dancing in the outdoor pavilion were provided for the evening's entertainment. After extensive deliberation and no little worry, the Cleveland committee arranged this outdoor carnival program to take the place of the almost traditional banquet. If any doubts remained as to the success of such a departure from a formal program, they certainly were decisively obliterated by the results of the experiment.

### Golf

With two major trophies and many valuable prizes offered to winners of golf events, and with the long-standing Mershon tennis trophy supported by other attractive prizes for event winners, the noteworthy sports program provided for the summer convention by the Cleveland committee attracted wide attention, but merited more participants. Two prominent and highly exclusive Cleveland country clubs, Mayfield and Canterbury, graciously extended the courtesy of their facilities for the golf tournaments, while the annual tennis tournament was played on the University Club courts through the courtesy of that organization.

As announced in Electrical Engineering (Sept. 1931, p. 761) the original Mershon golf trophy, which had withstood competition since 1912, last year became the permanent property of L. F. Demming (A'11) of Philadelphia, Pa., as a result of his having twice won the right to have his name engraved on it, in 1916 and in 1931. This year, a new trophy was given by Past-President Ralph D. Mershon to be competed for by match play on a handicap basis, as heretofore, and subject to permanent possession by virtue of 2 winnings by an Institute member. The 16 men having the lowest net scores in a preliminary qualifying round were privileged to play through 4 successive elimination rounds to determine the ultimate winner.

A new trophy also was made available this year by Past-President William States Lee. This trophy will be awarded annually at the summer convention to the Institute member having the lowest net score for 36 holes, of which the first 18 may be the general qualifying round. Another innovation was the District Team event. Each District was privileged to enter a team of not more than 6 nor less than 4 players. The team having the lowest total gross score for 36 holes (4 men) was adjudged by the Cleveland sports committee as being the championship District team, and each of the 4 players on one team having the lowest total gross score for 36 holes was designated to receive a suitable individual trophy. Handicaps were based upon the 5 best 1931 scores made by the players on their regular courses, the 5 scores being averaged and the difference between that average and the par for the player's course noted. For medal play, $^4/_5$ of this difference was allowed as the A.I.E.E. tournament handicap; for match play, $^3/_4$ of the difference was allowed as the handicap.

Out of a field of 45 formal entrants, the 16 that qualified for the golf tournaments included: H. O. Anderson (A'27) New York, N. Y.; E. S. Atkinson (M'31) Battle Creek, Mich.; A. B. Cooper (M'16) and H. C. DonCarlos (F'18) Toronto, Ont., Canada; Cecil Gray (M'30) Richmond, Va.; R. A. Monroe (A'30) Pittsburgh, Pa.; G. V. Smith (M'28) Mansfield, Ohio; C. E. Stephens (M'22) New York, N. Y.; A. H. Sweetnam (M'18) Boston, Mass.; D. S. Young (A'28) Chicago, Ill.; L. M. Keating (A'22), L. R. Keiffer (A'22), G. A. Kositzky (F'29), Frank Quigley (A'32), S. B. Taylor (M'26), and C. H. Teskey (A'32) of Cleveland, Ohio. The second flight was narrowed to Anderson, Atkinson, Gray, Keiffer, Quigley, Stephens, Sweetnam, and Taylor, of whom the first four won their way into the third flight. The championship flight was fought between Atkinson and Keiffer with final honors and the Mershon Trophy going to Mr. Keiffer whose handicap was 19. The Lee Trophy was won by C. H. Teskey whose handicap of 7 gave him a net score of 143 for 36 holes against a par of 143.

Additional events provided for by the sports committee, and the winners of prizes therein, were:

1st low gross, C. H. Teskey, 79.
2nd low gross, G. A. Kositzky, 85.
1st low net, L. M. Keating, 72 (83 − 11).
2nd low net, A. H. Sweetnam, 73 (88 − 15).
1st blind bogey (72–88), G. V. Smith, 86.
2nd blind bogey (89–100), G. R. Canning, 96.
3rd blind bogey (101–130), G. V. Mueller, 102.

The foregoing special events were played in connection with the qualifying rounds at the Canterbury Club Monday, June 20. The following events were played in connection with Tuesday's match play at Mayfield Club:

Proximity of approach to No. 4 hole, G. R. Canning, 14 ft.
Proximity of approach to No. 17 hole, C. G. Ramsay, Manchester, England, 5 ft.
Low gross for 7 pre-selected holes, W. S. Lee, 31 (par 27).
Low net score, L. R. Keiffer, 68 (87 − 19, par 71).

Further events at Canterbury, in connection with the second flight:

Low net score, E. S. Atkinson, 70 (92 − 22, par 72).
Proximity of approach to No. 3 hole, C. G. Ramsay, 47 in.

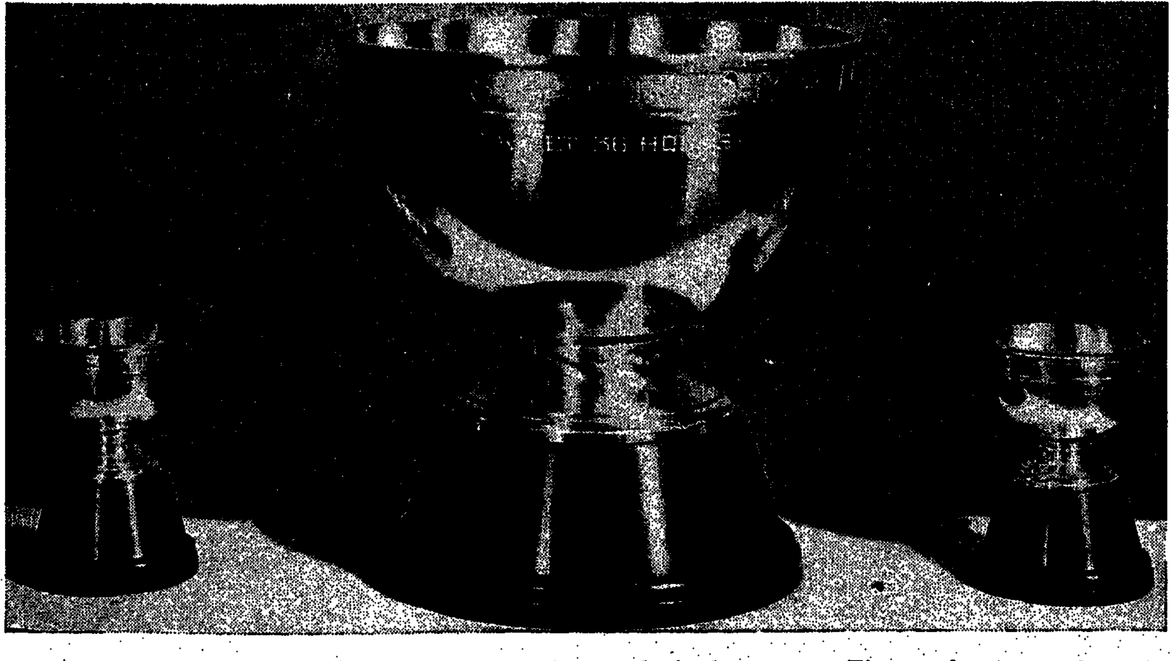
District No. 2 (Middle Eastern) took the team competition, L. M. Keating, G. A. Kositzky, G. V. Smith, and C. H. Teskey bringing in a total gross score of 691 for 36 holes (par 572).

### Tennis

With only 6 formally entered in the annual tennis tournament, the competition was not so widespread as in golf, but produced some lively sets and close scores. With the Mershon tennis trophy awaiting the winner of the men's singles the most active competition was in the singles events, although the Cleveland sports committee had prizes for the winners and the runners-up in each of the several events. With U.S. Lawn Tennis Association rules governing, all preliminary matches were decided by the best 2 out of 3 sets, the finals by the best 3 out of 5. The Mershon trophy is available to Institute members, the winner being recognized by having his name engraved on the cup and receiving a photograph of it, unless his be a second winning, in which event the cup passes permanently into his possession. With the addition of R. A. Monroe's name as the 1932 winner, the names engraved on the cup will be as follows:

1927—G. A. Sawin (M'13) East Pittsburgh, Pa.
1928—P. H. Hatch (M'29) Stamford, Conn.
1929—A. J. Gowan (A'23) St. Petersburg, Fla.
1930—E. F. Lopez (M'18) Mexico City, Mex.
1931—J. K. Peck (A'27) New York, N. Y.
1932—R. A. Monroe (A'30) Pittsburgh, Pa.

G. H. Gildersleeve (A'22) of Cleveland was runner-up; P. L. Alger (F'30) of Schenectady, N. Y., and E. F. Lopez (M'18) of Mexico City were eliminated in the semi-finals.



**The Lee golf trophy, 14 in. in diameter, for 36-hole low net. The replicas are 5 in. in diameter, one goes to each winner, whose name also is engraved on the big cup**

### Committees

The Cleveland general convention committee consisted of Robert Linsay, *honorary chairman;* G. A. Kositzky, *chairman;* A. M. MacCutcheon, *vice-chairman;* G. B. Schneeberger, *secretary-treasurer;* and F. E. Snell, *Cleveland Section secretary-treasurer.* To these leaders much credit must be given for the effective planning of affairs and for many of the novel and highly successful features included. The subcommittees and the affairs for which they were responsible are as follows:

**Banquet**—B. W. David, *chairman,* E. W. Henderson, L. E. Knapp, C. S. Ripley, D. Schregardus, and G. V. Smith.

**Entertainment**—C. N. Rakestraw, *chairman,* W. H. LaMond, T. D. Owens, C. S. Ripley, and L. A. S. Woods.

**Finance**—G. E. Miller, *chairman,* H. J. Dible, H. Dingle, A. D. Fishel, G. H. Gildersleeve, W. H. LaMond, H. L. Martien, R. L. Rathbone, W. M. Skiff, G. E. Snider, S. B. Taylor, E. F. Whitney, and E. A. Williford.

**Hotels**—I. H. Van Horn, *chairman,* J. Sayre Christie, L. R. Keiffer, and W. H. Stiner.

**Ladies Entertainment**—Miss Deany C. LaZan, *chairman,* Mrs. L. D. Bale, Mrs. F. W. Braund, Mrs. Henry B. Dates, Mrs. B. W. David, Mrs. Howard Dingle, Mrs. C. L. Dows, Mrs. E. J. Edwards, Mrs. E. W. Henderson, Mrs. G. A. Kositzky, Mrs. J. C. Lincoln, Mrs. A. M. Lloyd, Mrs. A. M. MacCutcheon, Mrs. E. H. Martindale, Mrs. C. N. Rakestraw, Mrs. G. B. Schneeberger, Mrs. J. M. Smith, Mrs. F. E. Snell, and Mrs. I. H. Van Horn.

**Meetings and Papers**—J. M. Smith, *local representative.*

**Publicity**—E. H. Martindale, *chairman,* C. H. Bunch, F. E. Harrell, Fennel Smith, and S. B. Taylor.

**Reception and Information**—H. B. Dates, *chairman,* C. J. Clements, H. J. Dible, R. C. Hardy, F. E. Harrell, J. C. Lincoln, P. D. Manbeck, R. S. McIntosh, R. C. Putnam, and R. L. Rathbone.

**Registration**—C. L. Dows, *chairman,* R. A. Carle, W. H. Fisher, F. A. Norris, F. Von Voightlander, and Thomas Wray.

**Sports**—A. M. Lloyd, *chairman,* Geo. Canning, W. G. Darley, J. L. Finnicum, W. E. McFarland, L. E. Miller, C. S. Ripley, and G. V. Smith.

**Technical Sessions**—H. L. Wallau, *chairman,* W. E. McFarland, J. J. Pokorny, and W. C. Saker.

**Transportation**—F. W. Braund, *chairman,* A. D. Fishel, G. H. Gildersleeve, H. T. Killingsworth, G. H. Mills, and C. E. Winegartner.

**Trips**—L. D. Bale, *chairman,* J. Callahan, Arthur Eastman, M. R. Gowing, C. A. Harrington, R. A. Hudson, A. H. Nicholson, and H. W. Pinkerton.

## Outline of Minutes of 1932 Annual Meeting

With President C. E. Skinner presiding, the annual meeting of the American Institute of Electrical Engineers was held at the Hotel Cleveland, Cleveland, Ohio, as the opening session of the annual summer convention, Monday morning, June 20, 1932.

The annual report of the board of directors was presented in abstract by H. H. Henline, acting national secretary. Printed copies were distributed to members in attendance and are available to any member upon application to Institute headquarters, New York, N. Y. The report, which constitutes a résumé of the activities of the Institute during the fiscal year ending April 30, 1932 shows a total membership on that date of 17,550. In addition to the 3 national conventions and 2 District meetings, 1,632 meetings were held during the year by the local organizations of the Institute in the principal cities and educational institutions in the United States, Canada, and Mexico. The report will appear in full in the quarterly TRANSACTIONS of the Institute.

The report of the committee of tellers on the election of officers of the Institute was presented, and in accordance therewith President Skinner declared the election of the following members taking office August 1, 1932:

*President:*

H. P. Charlesworth, vice-president, Bell Telephone Laboratories, Inc., New York, N. Y.

*Vice-Presidents:*

J. Allen Johnson, chief electrical engineer, Buffalo, Niagara & Eastern Power Corporation, Buffalo, N. Y.

E. B. Meyer, vice-president, United Engineers & Constructors, Inc., Newark, N. J.

K. A. Auty, sales engineer, Commonwealth Edison Company, Chicago, Ill.

G. A. Mills, chief engineer, Central & South West Utilities Company; vice-president, Pecos Valley Power & Light Company, Dallas, Tex.

C. R. Higson, superintendent of distribution, Utah Power & Light Company, Salt Lake City, Utah.

*Directors:*

G. A. Kositzky, chief engineer, The Ohio Bell Telephone Company, Cleveland, Ohio.

A. H. Lovell, assistant dean and professor of electrical engineering, University of Michigan, Ann Arbor, Mich.

A. C. Stevens, in charge, educational sales, General Electric Company, Schenectady, N. Y.

*National Treasurer:*

W. I. Slichter, professor of electrical engineering, Columbia University, New York, N. Y.

The board of directors for the next administrative year, beginning August 1, 1932, will consist of these officers, together with the following hold-over officers: C. E. Skinner (retiring president), East Pittsburgh, Pa.; W. S. Lee, Charlotte, N.C.; W. B. Kouwenhoven, Baltimore, Md.; W. E. Freeman, Lexington, Ky.; P. H. Patton, Omaha, Neb.; A. W. Copley, San Francisco, Calif.; L. B. Chubbuck, Hamilton, Ont.; J. E. Kearns, Chicago, Ill.; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New York, N. Y.; A. B. Cooper, Toronto, Ont.; A. E. Knowlton, New York, N. Y.; R. H. Tapscott, New York, N. Y.; L. W. Chubb, East Pittsburgh, Pa.; B. D. Hull, Dallas, Tex.; H. R. Woodrow, Brooklyn, N. Y.

President Skinner then congratulated President-Elect Charlesworth upon his election and presented him with the president's badge. Mr. Charlesworth responded with a brief address, which was enthusiastically received.

The report of the committee on award of Institute prizes, as published in the June 1932 issue of ELECTRICAL ENGINEERING, p. 418 was read by W. H. Harrison, chairman of the committee of award, after which the prizes were presented by President Skinner.

The Lamme Medal for 1931, which, as announced in the March 1932 issue of ELECTRICAL ENGINEERING, p. 209, had been awarded to Giuseppe Faccioli (A'04, F'12) of Pittsfield, Mass., was presented.

The annual presidential address then was delivered by President Skinner. (See p. 472–6.)

Adjourned.

(*Signed*) H. H. HENLINE
Acting National Secretary

## Officers, Delegates, and Members Hold Conferences in Cleveland

On Monday and Tuesday afternoons, June 20 and 21, 1932, the conference of officers, delegates, and members of the Institute was held at Cleveland, Ohio, as part of the recent summer convention. This conference was under the auspices of the Sections committee and the committee on student Branches. Present at this conference were delegates from 49 of the 60 Sections, 9 of the 10 District secretaries, and counselor delegates from 7 of the 9 Districts in which committees on student activities have been organized, as well as officers, officers-elect, and other members.

After a brief opening session on Monday afternoon, sessions A and B were held in parallel E. S. Lee, chairman of the Sections committee, presiding over session A devoted to Section activities, and Prof. W. H. Timbie, a chairman of the committee on student Branches, presiding over session B which dealt with problems concerning the Branches and Enrolled Students of the Institute. Tuesday afternoon was devoted to a joint meeting of the two groups to discuss subjects of common interest.

The topics in a conference program, which had been mailed to delegates and others in advance, are given in the following outline:

**Monday, June 20, 2:00 p.m.**

1. Opening of Conference:
Announcements by Everett S. Lee, Chairman of the Sections Committee
2. Remarks by President C. E. Skinner
3. Remarks by President-Elect H. P. Charlesworth
4. Remarks by Acting National Secretary H. H. Henline
5. Division into parallel sessions of Section and Student Branch delegates and members

**Session A—Section Meeting—Everett S. Lee Chairman**

6. Making the Institute of even greater value to the individual member
    a. The advantages of Institute membership—Everett S. Lee
    b. How the membership committee brings these advantages to the attention of prospective members—R. L. Kirk
    c. How the publications of the Institute maintain membership—E. B. Meyer
    d. How the committees of the Institute maintain membership—Prof. W. B. Kouwenhoven

e. How the Sections of the Institute maintain membership—J. J. Shoemaker
f. Problems of the finance committee—C. E. Stephens

**Intermission**

**Discussion**

**Session B—Student Branch and Enrolled Student Meeting—Prof. W. H. Timbie, Chairman**

7. Methods of teaching "Safety" to students
8. Organization of engineering clubs in local high schools—Prof. J. T. Walther and F. C. Young
9. Is it advisable to make student attendance at Branch meetings compulsory?
10. Suggestions for improving ELECTRICAL ENGINEERING
11. Suggestions for securing delegate representation for Branches located in Districts having fewer than 3 Branches
12. Student participation in District conventions—C. E. Baugh
13. Nature and content of program—Prof. M. S. Coover
14. Should some organization similar to Student Branches be set up in trade and industrial schools?—Prof. W. J. Seeley
15. Approved list of engineering colleges—G. L. Weller
16. Cannot the customary appropriations from headquarters to Student Branches be paid in advance as is done in the case of Sections?

### Tuesday, June 21, 2:00 p.m.

**Session C—General—Everett S. Lee, Chairman**

17. The professional status of the engineer—Prof. C. F. Scott
18. Legislation affecting the engineering profession—L. W. W. Morrow
19. Special committee on Institute policies—C. E. Stephens

**Discussion**

**Intermission**

20. Section and Branch cooperation
21. The coming year—H. P. Charlesworth

Copies of the annual report on Section and Branch activities for the fiscal year ending April 30, 1932 were distributed. These may be secured without charge to Institute members by applying to headquarters.

As indicated by the program, many subjects of great importance to the Institute were discussed. At the Section meeting, considerable attention was devoted to the matter of transfers, while at the student Branch and Enrolled Student meeting, much encouragement was given the formation of engineering clubs in high schools and the matter of providing talks before high school groups to be given by prominent and capable engineers.

RECOMMENDATIONS ADOPTED

The principal recommendations to the board of directors which were adopted are summarized briefly as follows:

1. Clarification of the relations between Associate and Member dues and the requirements for admission to the grade of Member.
2. Joint action by the Institute and other engineering societies to encourage the formation of engineering clubs in high schools.
3. The publication of one "feature article" in each issue of ELECTRICAL ENGINEERING.
4. The submission, by Institute headquarters to geographical District committees preparing for District meetings, of certain definite suggestions regarding the formation of a sub-committee to prepare for a student session and to make suitable arrangements for all phases of student participation in the meeting.

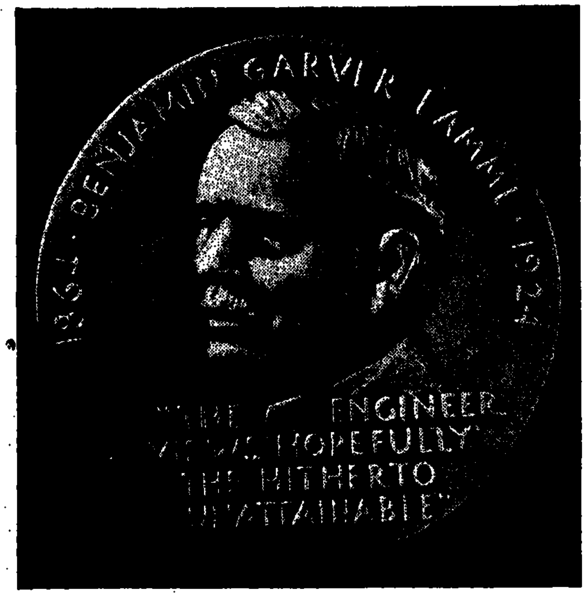
All of these recommendations were considered at the meeting of the board of directors held on June 22, and the following actions were taken (the numbered paragraphs refer to the corresponding recommendation):

1. Appointment of a special committee was authorized.
2. Referred to Institute representatives on the conference on certification into the engineering profession.
3. Referred to the publication committee.
4. Approved.

An abstract of the proceedings of the entire conference will be printed in pamphlet form and mailed to all delegates present; also to Institute, Section, and Branch officers. Any member of the Institute may secure a copy without charge by applying to headquarters.

## Lamme Gold Medal for 1931 Awarded

FORMAL presentation of the Lamme Gold Medal established by provision of the will of Benjamin Garver Lamme (deceased July 8, 1924) for the encouragement and recognition of "meritorious achievement in the development of electrical apparatus or machinery" took place June 20, 1932 at the annual business meeting of the A.I.E.E. during the summer convention at Cleveland, Ohio, with GIUSEPPE FACCIOLI (A'04, F'12) retired associate manager of the Pittsfield (Mass.) works of the General Electric Company, medalist for 1931. Mr. Faccioli (see p. 209, ELECTRICAL ENGINEERING, March 1932) was chosen to receive this award "for his contributions to the development and standardization of high-voltage oil-filled bushings, capacitors, lightning arresters, and numerous other features in high voltage transformers and power transmission." The first A.I.E.E. award of the Lamme Medal, made in 1928, was to A. B. FIELD (A'03, F'13) consulting engineer, Manchester, Eng., subsequent medals going to R. E. HELLMUND (A'05, F'13) chief electrical engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and W. J. FOSTER (A'07, F'16) consulting engineer, retired, General Electric Company, Schenectady, N. Y.



By Mr. Lamme's will, two other similar bequests were made, one to Ohio State University, the recipients of this medal to be a graduate or graduates of any of the university's engineering branches and the award to be "for meritorious achievement in engineering or the technical arts." The Lamme medals of Ohio State University will be presented this year to A. V. BLEININGER, chemist to the Homer Laughlin China Company, and to R. D. MERSHON (A'95, F'12 and past-president), consulting engineer and chemist, New York, N. Y.

## Junior Engineers Plan Industrial Projects

An interesting project program for junior members has been carried on successfully for some time by the Western Society of Engineers of Chicago, Ill., and more recently was taken up actively by the Cleveland (Ohio) Engineering Society. Junior members of these societies have organized themselves into fictitious holding, construction, and operating companies, and as such will undertake to solve the various problems that confront a typical industrial organization in undertaking new or enlarged operations including new manufacturing plant facilities.

The fundamental idea of the activity, as far as the societies are concerned, is to provide a continuity of interest in their junior member programs and to make these programs of definite interest and value to the junior members by giving the maximum number a definite responsibility in the various projects. The juniors consulted local firms having to do with the design, erection, and equipment of industrial buildings, and obtained from such firms the original specifications which had been given to the firm by the owners of a typical industrial project. With these plans in hand the junior members of the societies organized themselves into the necessary hypothetical finance, construction, and operating companies with related subsidiary units to study the various problems involved.

The junior members sent in formal "applications" for positions in the hypothetical companies outlining their qualifications, etc. The junior personnel of the various "companies" and "departments" will handle all of their own investigations, analyses, and design and operating problems, and will follow the work through to a complete "plant" design to meet economically the production and marketing requirements as determined by the various studies. After these plans have been completed they will be checked, through the courtesy of the local firms, against the actual solutions to the original problems, and against the actual plants themselves.

These activities seem to have aroused great interest among the junior members of both the Chicago and the Cleveland societies, and it seems probable that many of the Student Branches of the Institute might, to advantage, undertake similar projects with the helpful cooperation of related local sections.

# Summarized Review of Some Providence Meeting Discussions

PRINCIPAL discussions of Providence District meeting papers are summarized herewith. The papers to which these discussions refer were abstracted in ELECTRICAL ENGINEERING for April 1932, p. 263–7.

Only discussion submitted in writing in accordance with governing A.I.E.E. rules is summarized. Complete discussion, together with all approved papers, will be published in the TRANSACTIONS.

### PARALLEL-TYPE INVERTER

W. M. Goodhue (Cambridge, Mass.) described experiments which showed that static condensers may be omitted also when the a-c. line is replaced by a salient-pole damper winding synchronous motor. A 6-phase circuit with 6 thyratrons was used because it was preferable to operate the motor polyphase. The grids were excited by a polyphase induction phase-shifter consisting of a slip-ring induction motor with the rotor turned by a handwheel and worm drive, and insulating transformers for the rotor output. This phase-shifter was supplied directly from the terminals of the synchronous motor so that the inverter was permanently locked in step with the motor, and would automatically follow any speed changes. It was explained that the synchronous motor took load up to the maximum rating of the tubes, and showed no tendency to hunt or to fall out of step even when the shaft load was suddenly changed.

### ELECTRIC AND MAGNETIC UNITS

L. C. Eddy (Riverside, R. I.) believed that the general relations of units presented in the paper might prove to be of ultimate value for more thoroughly understanding universal relations of even certain forms of life. Both radio-activity and magnetism depend on certain relations or numbers of electrons or atoms much as animal life itself appears mainly where carbon is present in more or less definite relations with other elements.

### PERFORMANCE CALCULATIONS ON INDUCTION MOTORS

H. R. West (Pittsfield, Mass.) discussed this subject and advocated using a method of calculation which would give the desired accuracy with the least labor. He believed that the results of algebraic analyses, arranged in systematic form such as Mr. Veinott is using, could be used more profitably than they are at present.

R. E. Hellmund (East Pittsburgh, Pa.) discussed and explained why the discrepancy between the results obtained from load tests and those obtained by calculating methods from no-load values and other motor constants has been greater than it was 20 years ago. The up-to-date motors with smaller dimensions have higher flux densities and also more ampere conductors within a unit of space than was found in the earlier ones which most likely means in general more ampere conductors per slot than in the older designs. Then the zigzag and slot leakage fluxes would increase, tending toward greater saturation at load, especially in the tooth tips of partially closed slot machines. Since all theories deriving motor performance from the motor constants neglect the effect of saturation, he explained it was not surprising that in the modern designs there should be a greater discrepancy between such calculated results and tests made under actual load conditions.

P. C. Smith discussed several points in this paper and he believed the method permitted quick approximations or accurate calculations as desired. He questioned, however, the influence of friction and windage on the current through the shunt circuit and he did not believe that core loss always decreased with the load. In the determination of secondary loss in cases where the actual slip was available, he believed it might be advisable to substitute this for the secondary resistance.

Another discussion by P. H. Trickey (Springfield, Mass.) stated that he had used the author's method of calculation for over a year for both single-phase and polyphase motors rated between 2 hp. and 3 watts output and obtained very satisfactory results.

### STRAY-LOAD LOSS IN INDUCTION MOTORS

O. C. Rutledge (New Haven, Conn.) compared the results obtained in the paper by placing them on a percentage basis taking the input-output method as 100 per cent for each case. His analysis showed that method *A* gave low values while methods *B* and *C* gave permissible average values but there was a considerable spread from minimum to maximum. Mr Rutledge also presented curves obtained from tests on a 10-hp. wound rotor machine. Comparisons of both the input-output and direct methods were shown in curves plotted for loss against line current. These curves indicated that in the vicinity of full load the loss by direct measurement is of the same order of magnitude as that by input-output determination. However, the shape of the curve still left open the question as to whether or not the pulsation loss by the d-c. method is a correct representation of the true pulsation loss under load.

Messrs. O. C. Schoenfeld and S. F. Henderson (East Pittsburgh, Pa.) discussed the paper and they believed the method outlined had some merits although not theoretically correct nor could they check it experimentally. In their opinion proper consideration had not been given to the effect of saturation which could have considerable influence and as a result the d-c. short-circuit method gave values in excess of those obtained under normal load conditions. A tabulation of their tests showed full load efficiencies and stray load losses for 6 motors. The results indicated that the method proposed did not give sufficiently accurate results and the conventional efficiency in several cases gave results closer to the input-output value although the error was in the opposite direction. In general, the correction factors proposed by Linckh were correct but, as they were based on only a few tests, they should be further checked. In conclusion, the discussers did not believe that the method proposed simplified facilities or shortened time testing.

L. E. Hildebrand (Lynn, Mass.) also discussed this subject and cited the difficulties with present test methods. He believed that in all practical work a conventional efficiency test including a conventional load loss is certainly superior to ignoring load loss. Also this test with an average crew and equipment should be superior to the impractical input-output test providing a method is used for determining a conventional load loss which gives consistently repeatable results approximately equal to the true load loss. It was believed that such a method should be legalized and that the author's method *D*, with *C* as a permissible alternative for single-cage motors, seemed practical for a tentative permitted method.

Another discussion by H. L. Barnholdt (East Pittsburgh, Pa.) took exception to the proposed method *D* for squirrel-cage induction motors because only one test was indicated comparing this method with the input-output test. While this checked quite closely it was believed that, if a number of tests were made, they might show as wide discrepancies as methods *A*, *B*, and *C*. Further tests and greater consistency of test results were suggested as necessary before attempting standardization. The discusser also suggested an arbitrary allowance, say $^3/_4$ per cent, to cover stray-load losses on large induction motors. Input-output tests could be made when opportune so as to revise the allowance.

Still another discussion on this subject by C. G. Veinott (East Pittsburgh, Pa.) commended the author for his endeavor to measure the stray-load loss in polyphase induction motors. He thought the paper brought out reasons why the Institute should make a distinction between large and small motors and should, in his opinion, recommend the directly measured efficiency (input-output method) for the small motors. This opinion was based on the importance of stray-load losses in small motors and the ease, cheapness, and reliability of the input-output method. It was believed the dividing line between methods should be in sizes above 3 hp.

P. L. Alger (Schenectady, N. Y.), chairman of the committee on electrical machinery, discussed this subject as follows:

"The general opinion expressed was that, while it is very desirable to establish a standard method for determining induction motor load losses, and while Mr. Koch's proposals are fundamentally sound, much yet must be done in the way of study and tests before any method can be adopted as a standard.

"There was general agreement that measurement of the rotational losses by driving the motor at normal speed with direct current in the stator winding is an essential element in any direct measurement of stray-load loss. A difficulty arises, however, in the determination of the correct secondary $I^2R$ loss to be subtracted from the total rotational losses.

"If the rotor $I^2R$ loss is determined on the basis of the resistance corresponding to normal load slip, the value obtained is too small, since it does not include the full frequency rotor iron and copper losses.

These errors are very large on deep bar or double squirrel-cage motors, and for this reason methods *B* and *C* are regarded as undesirable for general use.

"While determination of the rotor losses by measurement of the standstill torque at full load current almost gives theoretically correct results, it is very difficult to carry out in practise on small motors, because of the irregularity of the torque position curve and the errors due to bearing friction.

"Determination of the rotor losses by measuring the impedance watts input and subtracting from it the primary $I^2R$ loss is convenient and approximately correct in the case of overhung slot motors, but it gives a value of rotor loss which is slightly too large, and, therefore, gives a value of stray-load loss somewhat too small. This error is somewhat offset by the existence of saturation in the flux leakage paths under normal load conditions. It seems practical, therefore, to get accurate results by this method, if a simple correction factor of perhaps 10 per cent is applied to the primary copper loss.

"In conclusion, method *A* should form the basis of standards for stray-load loss measurement in the case of overhung primary slot motors of one hp. and larger, with the addition of a multiplying factor of perhaps 1.1 for the primary copper loss on the standstill impedance test. Method *D* should form the basis of standards for stray-load loss measurement in the case of open primary slot motors (which are generally built in ratings of 20 hp. and larger). Direct input-output tests should remain standard for fractional hp. motors and should remain optional for larger motors.

"The induction motor subcommittee of the committee on electrical machinery is now reviewing this problem, and plans to submit some definite recommendations on the subject to the standards committee in the near future."

### SYNCHRONOUS MACHINE CHARACTERISTICS

J. W. Butler (Schenectady, N. Y.) discussed this subject and analyzed mathematically the calculation of damping torque for comparatively large sustained oscillations. He also emphasized the equivalent circuit shown in Fig. 9 of the paper which can be used to calculate any sort of a transient in a machine, including resistance, within the assumptions made. One particular use which was made of the circuit was in calculating decrement curves, for a fault on a generator feeding an impedance load, considering the effect of the load resistance in the time constants and magnitudes of the current.

In connection with this subject (S. H. Wright) cited certain prime advantages of low and high resistance dampers. Low-resistance dampers, he explained, tend to rapidly damp out swings which occur during symmetrical circuit conditions. For 2-machine stability problems, or multi-machine problems, where there are no serious compound oscillations, high resistance dampers give higher transient stability limits, especially for the longer clearing times, such as greater than 16 cycles where $f = 60$ cycles per sec. However, in the future, clearing time will probably be reduced to 8 cycles or less; interconnections and other factors will make compound system oscillations more important, so that greater damping ability, under symmetrical circuit conditions, of low-resistance dampers would become of paramount importance.

### CAPACITOR MOTOR DESIGN

L. A. Doggett (State College, Pa.) questioned the theory of the capacitor motor developed on the assumption of sine waves. An oscillogram of current waves taken when a capacitor motor running light was operating from practically a sinusoidal source showed values 4.4, 6.1, and 2.4, respectively, for line current, capacitor-phase current, and main-phase current. The wide departure of these currents from sinusoidal shape throughout the whole range of operation was brought out by an $I^2R$, $I^2X$ analysis of the load run test data. The wide discrepancies in tabulated $I^2X$ values was believed to indicate the presence of large harmonics.

P. L. Alger (Schenectady, N. Y.) commented on several points of L. A. Doggett's discussion. In his opinion the discussion was incomplete, when it simply pointed out the presence of harmonics and questioned the validity of the theory which neglects them, without some figures showing the actual magnitude of the errors they may introduce. If the ratio of the actual to the assumed sinusoidal copper losses were calculated from the test oscillograms, the results presented would be more interesting. In reference to the comparison of line $I^2X$ with those of the 2 branches the discusser pointed out that 3 out of the 9 cases checked closely and he believed that discrepancies in the other cases could be due to the inaccuracies inherent in the calculation from observed values of voltage, current, and watts.

Another discussion by C. G. Veinott (Springfield, Mass.) brought out that this paper showed the conditions which must be met in order to obtain operation equivalent to that of a 2-phase motor and incidentally brings to light important conclusions. For example, Fig. 1 in the paper showed that the ratio of capacitor phase turns to main-phase turns was of the order of the tangent of the power-factor angle of the motor when considered as a 2-phase motor with both phases like the main winding. It is, therefore, necessary to have control of the winding ratio as well as the external microfarads in order to obtain balanced operation. Consequently any polyphase motor cannot necessarily be operated as a polyphase motor from a single-phase source merely by the addition of a capacitor of suitable value in one phase.

### MULTIPLE CONDUCTORS

In connection with this subject Dr. Hillel Poritsky (Schenectady, N. Y.) described the method in which he obtained the exact solution for the maximum potential gradient of 2 cylinders having charges equal in magnitude and of the same sign. This required doubly periodic or elliptic functions for its treatment and the formula obtained is applicable to determine the critical disruptive voltage of a double conductor transmission circuit.

S. B. Crary (Schenectady, N. Y. ) discussed the comparison of maximum potential gradient obtained by approximate and correct formulas for the case of multiple conductors with charges of equal magnitude and the same sign. He explained that for practical cases eq. 5(*c*) in Miss Clarke's paper was developed. This formula corrects for the field distortion due to the conductors of the same phase by making 2 assumptions. First, the field distortion due to the conductors of the other phases and the ground plane is negligible. Second, the field produced by the other conductors of the same phase may be considered uniform in the region of the conductor under consideration. The accuracy obtained by using this approximate eq. 5(*c*) was shown graphically compared with the results obtained by using Dr. Poritsky's formula. It was essentially correct for a ratio of spacing to conductor diameter as low as 5 to 1. Another curve showed that if field distortion were neglected for this ratio it would have resulted in an error of 15 per cent.

Another discussion by W. W. Lewis (Schenectady, N. Y.) considered the economical aspects of the problem. He pointed out that the large weight of conductors required heavy towers and short spans. Also to obtain continuously decreased reactance, increased capacitance, and increased corona starting voltage, it was desirable to maintain as closely as possible the spacing between conductors in the same phase and in the different phases. This would require special insulating arrangements and supporting and separating yokes which would increase the expense. The discusser gave cost data compiled as a result of a comparative study of split conductor 345 kv. and 230 kv. lines as compared with conventional lines of the same voltage. From these data it appeared that at 345 kv. the 2 conventional lines had about the same cost per kv. and same yearly charge as one split conductor line. However, 2 conventional circuits have a greater total capacity and have the obvious advantage that the total flow of power is not dependent upon one tower line. At 230 kv. the comparative costs and yearly charges were about the same; however, the conventional lines had a considerable margin of greater capacity.

W. S. Moody (Pittsfield, Mass.) also discussed this subject in relation to the suggested methods of obtaining the reactive voltage by the use of transformers having very high magnetizing current resulting from the use of air gaps in their magnetic circuit or separate reactances distributed along the line. He explained that even the slight air gaps commonly used in European transformer practise have proved a very troublesome feature and they are gradually being dropped for our interleaved core construction. The 4 very long gaps required would drive a very heavy flux into the winding space of the transformer. This would necessitate very small conductors to avoid excessive eddy losses in them and would thus greatly weaken the windings mechanically. The varying density of the flux along the wire space also would create great difficulty in a parallel connection of any portion of the windings. Therefore, distributed loading coils would be preferable to obtain the necessary reactive voltage.

# Plans to Proceed for Colorado River Aqueduct

Information has been received from California to the effect that the Supreme Court of California rendered a decision on June 2, 1932, that the bonds for the construction of the Colorado River aqueduct are valid. These bonds total $220,000,000 and were authorized by the 13 cities composing the metropolitan water district of southern California on September 29, 1931. The purpose of the bonds is to finance an aqueduct to supply the Los Angeles metropolitan area with water from the Colorado River.

The main aqueduct will be 240 miles long. Storage facilities for regulating the flow will be provided, as well as distribution lines for delivering the water to the existing systems in the cities of the metropolitan water district. Power for pumping will be secured principally from the government plant at Hoover Dam, supplemented by smaller amounts at various parts of the system. The total static pumping lift will be 1,583 ft. It is contemplated that an average flow of 1,500 sec.-ft. will be diverted from the Colorado River and carried over the high lands to the Los Angeles basin.

At present it is planned to construct a diversion dam to raise the water surface 72 ft., creating a reservoir of 716,000 acre-ft. capacity. An opportunity also is afforded for the development of 80,000 kw. of electrical energy.

Although this great project will require the employment of a large force of men, a word of warning has been expressed to discourage large numbers of men coming to the district in the hope of securing work. It is stated that men are now available in southern California in excess of all requirements for every opening that the aqueduct work can possibly afford for months to come.

**Radio Study in Copper Country.**—Amateur short wave radio station W9YX and W9XAW at the Michigan College of Mining and Technology, Houghton, Michigan, was opened in January 1931. Since that time experiments in radio transmission have been conducted, consisting largely of attempts to determine what type of transmitters and aerials are best suited to the station's locality, the Michigan copper country. The most difficult problem is to overcome the great day-to-day variation in range of consistent communication. Receptivity has been found to vary, although it changes less than the transmission range. The staff at the Michigan college has tested Hartley and tuned-plate, tuned-grid transmitters and modifications which it has devised. Satisfactory communication was established March 1, 1932 with the present set consisting of a 100-watt tuned-plate, tuned-grid transmitter for continuous wave work, and a low power 7.5-watt phone set. The station operates on 40 and 80 meters. Aerials experimented with have variations or modifications of the Hertz antenna, vertical types of Zeppelin, horizontal Zeppelin, and single-wire-fed matched impedance. In February 1932 the staff returned to the voltage-fed Hertz type used earlier. The next experiments will consist of studying the efficiency of ultra short wave lengths of from 3 to 5 meters.

# A Tribute to Frank J. Sprague

A meeting of appreciation and tribute to Frank J. Sprague (A'87, F'12, HM'32 and past-president) is to be held Monday, July 25, 1932, at 8 p.m. in the Engineering Societies Auditorium, 33 West 39th Street, New York, N. Y. Doctor Sprague, engineer, scientist, and inventor, is to be honored on the seventy-fifth anniversary of his birth for his long service to industry.

F. J. SPRAGUE

(Electrical Engineering for February 1932, p. 139–40 outlined the achievements of Doctor Sprague, a pioneer in electrical applications, principally of electric motors, railways, and elevators.)

The meeting is being held under the auspices of the Frank J. Sprague anniversary committee, Gano Dunn, *chairman*, and C. T. Hutchinson, 52 William Street, New York, N. Y., *secretary*. Presidents and secretaries of the leading engineering and related societies, as well as a large group of other prominent individuals, are assisting the committee. The program for the meeting is as follows:

"An Engineer's Contribution to the World's Welfare," Dr. John H. Finley.

"An Engineer's Contribution to Transportation," Frank Hedley.

"Frank J. Sprague—A Tribute," Rear Admiral S. S. Robinson, U.S.N. (Ret.).

Response: Frank J. Sprague.

Members of the assisting societies and friends are invited.

**An all-welded condenser,** reputedly the largest of its kind ever built, is one of the principal features of interest in the newly enlarged Kearny, N. J., steam-electric generating station of the Public Service Electric and Gas Company. The condenser contains 11,900 24-ft. tubes, and, with an expected water rate of 105,000 gal. per min., it is expected to handle the 780,000 lb. of steam per hr., required by the newly installed 75,000-kw. turbine generator set, the recent completion of which is reported as increasing the capacity of the Kearny station from 214,500 to 289,500 kw.

# Elevators for Carlsbad Cavern

To eliminate a 750-ft. climb that formed an irritating but necessary part of a visit to the major features of the Carlsbad Cavern, N. M., the national park service has provided a passenger elevator by which tourists are taken to the main level of the cave. The development consists of providing a high-speed passenger elevator of modern design and safety equipment in a shaft drilled simultaneously from top and bottom through 754 ft. of rock to the main cavern level. The cavern in this national park contains the largest series of underground caverns ever explored, extending through 50 miles of known chambers and corridors.

The shaft size was 6 ft. 10 in. x 14 ft. 3 in. inside the concrete lining. The shaft was lined with gunite varying in thickness from $^1/_4$ in. to several inches. The elevator, house, shaft, and guide construction are entirely fireproof, with guide-rail supports of *I*-beam sections set into the rock walls.

The steel headframe is the center of a 3-story shaft house. The first floor is occupied by the elevator landing, the second floor is used as a generating room, and the third contains the machinery and controls. The roof will be used as an observation gallery. A novel feature of this building will be the provision for natural heating, cooling, and ventilation, using air from the cavern, which is always at a temperature of 56 deg.

The elevator is of modern electric type with self-leveling cage carrying 12 persons. It is planned to operate at a speed of 700 ft. per min. One elevator has been installed at the present time, and a second will be added later in the other compartment. With the exception of a few of the elevators in the Empire State Building, the present installation is the longest single-lift passenger elevator in the world. The equipment contains all automatic safety devices found in usual building installations.

—Excerpts from an article by F. A. Kittredge and W. G. Attwell, appearing in *Engineering News-Record*, June 9, 1932.

**Philadelphia Engineers Are Helping Each Other.**—An organization has been formed of unemployed engineers, who, true to their vocation, are doing their bit toward keeping up the morale of their fellow engineers, and serving industry by helping it in securing competent technical help. This organization is the technical service committee of the Engineers' Club of Philadelphia, Pa., located at 1317 Spruce St. The committee is an association of 12 national engineering societies, and its cooperation with the state employment commission makes it an organization of permanence. A very complete group of 850 highly technical men is ready to fill any gap that may exist in an organization. As stated by the committee, it is well worth noting that these technical men are plentiful now, but when the pendulum begins to swing upward again they will be scarce, and the employers who will take advantage of this opportunity now will have the most stable organization when business is back to normal.

# Letters to the Editor

## Eliminating Transients in D-C. Welding Generators

*To the Editor:*

In addition to the interesting papers by Messrs. S. R. Bergman ("Transforming Reactor Improves D-C. Arc Welding," Electrical Engineering, April 1931, p. 283–5) and by J. H. Blankenbuehler ("An Improved Welding Generator," Electrical Engineering, August 1931, p. 666–8) and the "Letter to the Editor" by C. J. Holslag ("Characteristics of Arc Welding Generators," Electrical Engineering, January 1932, p. 59) let me point out that I was probably the first to suggest the application of static transformers to d-c. generators supplied with multiple fields (separately excited and series fields for instance), in order to obviate the undesirable transients. In 1911, I took a French basic patent number 444,322, assigned to the "Société Alsacienne de Constructions Mécaniques," and some time later, the same idea was applied by R. Thury to high tension d-c. generators for constant current power transmission.

More recently, I patented the special application to arc welding generators, and in 1927 a full description of such improved generators was published in "Bulletin de la Société Alsacienne de Constructions Mécaniques" April 1927, p. 45; since 1928, they have been built by the French company "Als-Thom." Some years ago, complete information was given to American firms, but they were not interested in acquiring rights under my invention.

Very truly yours,
J. Bethenod (A'18)
(Consulting Engineer, 48 Quai d'Auteuil, Paris, France)

## Propagation Constant of a Transmission Line

*To the Editor:*

In the February 1932 issue of Electrical Engineering, p. 128–9, appeared an article by W. J. Creamer, Jr., "Propagation Constant of a Transmission Line" in which the author summarizes his problem and results thus: "The propagation constant of a transmission line usually is developed by means of differential equations...... A derivation of this constant which depends only on the application of Kirchhoff's laws and simple hyperbolic trigonometry is given below." I have the following comments to make:

1. There is nothing new in the method used by the author. Steady-state transmission theory in general may be and has been derived by the method used in the paper.

2. In deriving the result the author introduces an approximation which is unnecessary and is usually not made in deriving the propagation constant by this method.

In support of these comments, reference can be made to "High Frequency Alternating Currents" by Knox McIlwain and J. G. Brainerd, in which eq. 190 is the same as eq. 3 of the paper except that voltages rather than currents have been used; eq. 191 is the same as eq. 4 of the paper, and the derivation of the propagation constant of a line, as given on page 318, of the above-mentioned text-book, is more exact than that given in the paper. Incidentally it should be noted that the authors of the text-book cited clearly state that the material is not original, and indeed the method used in the paper is a relatively old one, known to antedate the text by some years.

Very truly yours,
H. C. Hart
(Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa.)

## Savings and Investment

*To the Editor:*

According to the Progress Report of the American Engineering Council ("The Relation of Consumption, Production, Distribution," Electrical Engineering, June 1932, p. 373–9), the principal cause of a business depression is that savings are made at a rate faster than investment. Such a statement needs a word of explanation. The true measure of savings is the amount of goods in existence. All that exists now has been saved from some past time, possibly saved for only a few minutes, or possibly for thousands of years, but it all has been saved. Investment consists of saving in some form that will yield a profit. When a man saves his old clothes to do dirty work in, that is saving but not investment. The excess of saving over investment literally refers principally to that type of saving. Yet it is perfectly evident that the committee had some entirely different idea in mind.

The report suggests that it is referring to money, that when the community as a whole takes in more money than it spends either for consumption of goods or it places in investment, then we have a depression. This appears to be the thought behind the report, but a little consideration is enough to show that the community cannot possibly do anything of the kind. Mr. Brown has a hat and Mr. Smith $3. Mr. Smith may keep the $3 and Mr. Brown keep the hat, or they can trade so that Mr. Brown will have the $3 and Mr. Smith the hat, but the money is saved just the same. It is still saved by some one, no matter how many times it is spent. All the money issued is saved, and no more can be saved, no matter what is done in business.

Possibly the hoarding of money is referred to. There are times when money is hoarded in unreasonable amounts, but there is no reason to think that money was so hoarded in 1929. That seems to have been a time of free spending rather than hoarding. Money hoarding has been blamed for many things, and it doubtless has caused some damage, but evidence that it is a major factor in the business cycle is entirely lacking.

It is hard to tell what the committee had in mind when it referred to the excess of savings over investment. We cannot take the words in their strict literal meaning. That would produce a result evidently absurd. We cannot take them to mean saving money, for the community as a whole cannot change the amount of money saved. I cannot think of any interpretation of the statement that will stand examination on sound principles of economics. But whether the committee is advocating a sound or unsound economic program, when they use a statement as the foundation on which their reform program is based, this statement should at least be expressed so that there would be no doubt as to its meaning.

Very truly yours,
A. W. Forbes (A'12)
(Forbes & Myers, Worcester, Mass.)

## Injuries From Electric Shock

*To the Editor:*

I have read with considerable interest over the period of the past few months, the comments in "Letters to the Editor" in connection with the published results of Doctor Kouwenhoven's researches on electric shock, particularly the protests of our anti-vivisectionist members.

There can be no question but that these protests are in good faith and registered in a sincere belief that the taking of life for any purpose is wrong; however, this is no place to argue the merits and demerits of surgical experiments upon living specimens. I would like to state myself definitely on the relation of electric shock to electrical engineering as a profession.

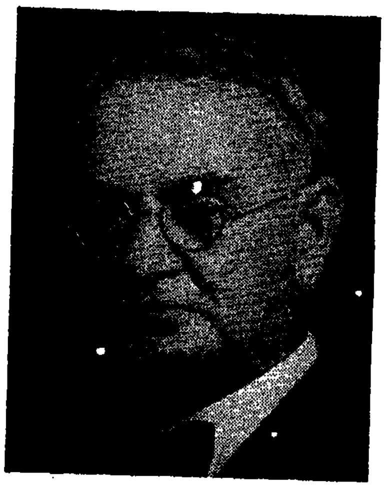
Cases of electrical shock are almost without exception the natural result of the increased use of electrical power, they usually have as a victim a person directly connected with the electrical industry, the discoverers of a victim of electric shock are in nearly all cases employees of the electrical industry and as such would administer efforts at resuscitation, and last but not least, the only individuals, with but few exceptions, who appear to have any interest in combating the results of electric shock are the insurance companies and the electrical industries.

The question of improved procedure and methods of relieving persons of the consequences of electric shock is of as much importance to the electrical industry, and the world, as is the problem of building surge-proof transformers, and the protection of transmission lines from flashovers, not only from a humanitarian point of view but also from the commercial standpoint. Improved safety devices and insulation standards have greatly lowered the hazards of the electrical worker, but there will always be found in experimental work and construction projects a comparatively high possibility of death from electrical injury. And the possibility of saving a few of these lives through knowledge gained through experiments with animals is worth all of the rats of Hamlin, and more.

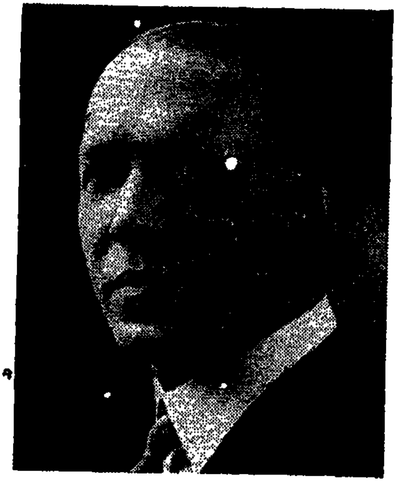
Whether or not these results should be published in the issues of Electrical Engineering can have but one answer. We of the electrical industry have no one but ourselves to protect us against electric shock; everything possible is done in the way of safety standards, but carelessness and chance are ever ready to take their toll. It is, therefore, left to us to forward and encourage in every possible way responsible research on electric shock and the prevention of death thereby, and that means both financial support and the publication of results.

Very truly yours,
F. W. Godsey (A'30) (310 Alden Ave., New Haven, Conn.)

# Personal



Kaiden-Keystone Studios
H. S. WARREN



R. N. CONWELL

Kaiden-Keystone Studios
A. E. SILVER

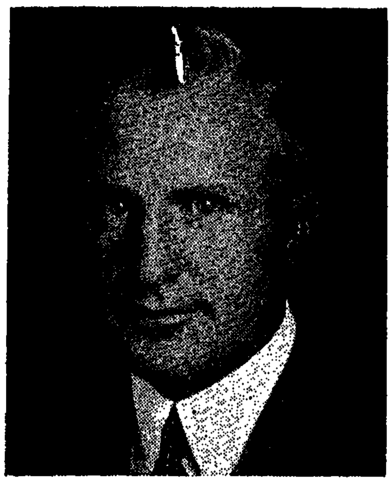
H. S. Warren (A'03, F'13) protection development engineer, the American Telephone and Telegraph Company, New York, N. Y., shares the 1931 A.I.E.E. national prize for best paper in engineering practise, which was awarded the symposium on coordination of power and telephone plant. Mr. Warren's contribution to this symposium was the paper "Status of Joint Development and Research on Low-Frequency Induction" in joint authorship with R. N. Conwell (A'15, F'31). A native of Oldtown, Maine, he went west in 1894 and entered upon an electrical engineering course at Leland Stanford, Jr. University, Calif. From this he was graduated in 1898 with his A.B. degree. His first practical electrical work was done while serving as electrician for the U. S. Fur Seal Commission. Immediately after graduation from the university he entered the employ of the Standard Electric Company of California, in San Francisco, and undertook the study of electrical constants and the transpositions for its projected 50,000-volt transmission line from Amador County to San Francisco. He next took a position with the California State Board of Harbor Commissioners and later in 1898 he engaged with the Nevada County Electric Power Company, Nevada City, Calif. But Mr. Warren's real life work has been in the field of communication. September 1899 he joined the American Bell Telephone Company, and since then he has devoted his entire effort to progress and improvement in this field. For many years he was in responsible charge of the design and development of some of the apparatus most vital to telephone systems. He designed and reduced to practical form, the loading coil which carried out the inventions of Doctor Pupin, designing cables and studying the loading of cables in connection with these inventions. He designed coil for, and reduced to practise also, the phantom circuit, an accomplishment not only highly interesting scientifically but one which made possible the operation of many thousands of miles of circuits. He is a member of Western Universities and the Engineers' Club, and past-president of the Telephone Society of New England.

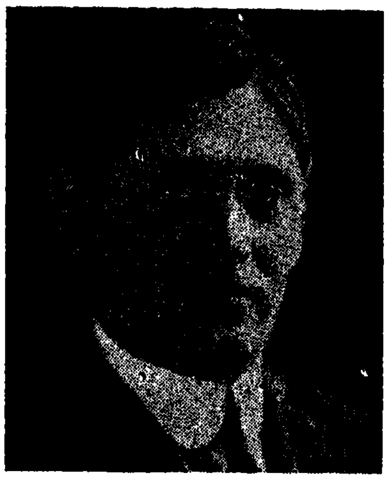
R. N. Conwell (A'15, F'31) transmission and substation engineer for the Public Service Electric and Gas Company, Newark, N. J., shares with his coauthor H. S. Warren (A'03, F'13) in the 1931 A.I.E.E. national prize for best paper in engineering practise, which was awarded the symposium on coordination of power and telephone plant. The title of their paper was "Status of Joint Development and Research on Low-Frequency Induction." Mr. Conwell, a native of Anderson, Ind., is a graduate of Purdue University and of the George Washington University, Washington, D. C. As engineer in charge of acceptance tests of the sewage pumping station for the sewer department of the District of Columbia, his first professional work was done. In 1911 he was employed as cadet engineer by the Public Service Electric Company of Newark, N. J., later as laboratory assistant, and chief of the materials division of laboratory testing.

In transition to his present work he became assistant engineer of the engineering department in charge of station and substation design, system protection, and general engineering work. In 1922 he was made transmission engineer of the distribution department. As such he has organized and placed in operation a complete system of load forecasting and planning for budget purposes. To secure a more efficient distribution of power and a better continuity of service, Mr. Conwell completely redesigned and reconstructed the transmission system of his company. In 1925 he was appointed to his present position. His contributions to technical literature and discussion have been abundant and his committee activities with the A.I.E.E., National Electric Light Association, American Standards Association, American Committee on Inductive Coordination, National Fire Protection Association, and the Association of Edison Illuminating Companies, all too numerous to list. He also has to his credit over 2 dozen patents granted and pending. He is the inventor of the present type of inverse current relay for transmission and line work as made by the Westinghouse Electric and Manufacturing Company, and has done outstanding work in the inductive interference field.

C. A. CHURCH

A. E. Silver (A'07, F'26) consulting electrical engineer for the Electric Bond and Share Company, New York, N. Y., was among those to receive the 1931 A.I.E.E. national prize for best paper in engineering practise, awarded the symposium on coordination of power and telephone plant, the paper "Trends in Telephone and Power Practise as Affecting Coordination" prepared by him and W. H. Harrison (A'20, F'31) being an integral part of the prize symposium. Mr. Silver who is a native of Dexter, Maine, received his early education there. Entering upon an electrical engineering course at the University of Maine, he was graduated with the class of 1902, and then entered the test department of the General Electric Company at Schenectady, N. Y. In 1904 he accepted a position with the Raleigh Electric Company, Raleigh, N. C., remaining over a period of years in charge of its meter department, and also working on switchboard construction, generating stations, and overhead lines. With the coming of a new régime, in 1906, the departmental work was divided into steam and electric activities, Mr. Silver remaining in charge of the electrical work. Later in that same year he accepted the position of chief engineer and electrical superintendent of the Carolina Power and Light Company, Raleigh, N. C., this company representing the consolidation of several central stations and street railway properties of that section, as well as transmission and hydroelectric plants of the vicinity. In 1910 he became electrical engineer of the Electric Bond and Share Company and removed to New York City. The work with this company included responsible charge of design of generating stations, substations, transmission and distribution systems. Mr. Silver has served on both the power generation committee and the power transmission and distribution committee of the Institute, and since 1915 has been actively connected with committee work of the National Electric Light Association, now serving as counselor of the overhead systems committee, and of the foreign systems coordination committee; a member of the special engineering committee on lighting and marking airways and of the N.E.L.A.–Bell Telephone system joint development and research committee; and vice-chairman of the engineering national section. He has served also on committees of other well-known and national organizations including the Bureau of Standards. He is a Fellow of the American


W. H. HARRISON


J. C. MARTIN

G. L. LILLIE

C. E. HOUSTON

Association for the Advancement of Science, and a member of the Montclair Society of Engineers, of Montclair, N. J.

W. H. Harrison (A'20, F'31) who with A. E. Silver (A'07, F'26) his coauthor of the paper "Trends in Telephone and Power Practise as Affecting Coordination" shares in the 1931 A.I.E.E. national prize for best paper in engineering practise, awarded the symposium on coordination of power and telephone plant, is plant engineer of the American Telephone and Telegraph Company, New York, N. Y. Mr. Harrison who was born in Brooklyn, N. Y., was graduated from the electrical engineering course of Pratt Institute, Brooklyn, and in 1909 joined the New York Telephone Company in New York City, as repairman. His work until 1915 included apparatus inspection, assembling, and wiring; then he accepted a position on telephone circuit design work with the Western Electric Company in its engineering department. Three years later he joined the engineering Staff of the American Telephone and Telegraph Company for general plant maintenance engineering work; and in 1924 was made equipment and building engineer with general supervision of the engineering and design (including layout) of subscribers' station and the central office plant of the Bell system. He became plant engineer in 1929, this appointment giving him charge of the engineering, design, and layout of all parts of the Bell system plant including system relations with other wire-using utilities. Among other achievements, Mr. Harrison is said to have brought order out of chaos in connection with a large and important merger of several telephone systems in California, where he accomplished the standardizing and improvement of maintenance features of telephone equipment and contributed greatly to the application to and adoption of mechanical systems for telephone plants in the United States.

J. C. Martin (A'12) electrical engineer of Middle West Utilities Company, Chicago, Ill., who with H. L. Huber (M'23) prepared the paper "Status of Cooperative Work on Joint Use of Poles" which was a part of the symposium on coordination of power and telephone plant shares in the 1931 A.I.E.E. national prize for best paper in engineering practise awarded to this symposium. Mr. Martin was born at Solon, Iowa, and obtained his early technical education by home study with the International Correspondence School. In 1903 he engaged with the Cedar Rapids and Iowa City Railway and Light Company, doing office work for 2 years after which he was advanced to construction, line, and power plant work. In 1911 he joined the engineering department of the Pacific Power and Light Company, first as distribution engineer, later being made chief engineer in charge of all design and construction work. During this period he was located at Portland, Ore. In 1917 the Pennsylvania Power and Light Company of Allentown, Pa., chose him as its chief engineer. Here he remained until 1920, when he became western editor of *Electrical World*, located in Chciago. His history with the operating department of the Middle West Utilities Company started in 1923. By the Pacific Power and Light Company he was considered a specialist on electrical distributing systems.

C. E. Houston (A'32) assistant, department of physics, Texas Technological College, Lubbock, Texas, has received the South West District prize for Branch paper presented during the year 1931, in connection with the presentation of his paper "Accumulation of High-Potential Static Charges on Transmission Lines During Sand Storms." Mr. Houston was born at Salado, Texas, and earned his B.S in E.E. from Texas Technological College in 1931. From 1927 to 1928 he was chemistry assistant at the college, and from 1930 to 1931, physics assistant. In 1930 while an undergraduate student he undertook research work on static charges on transmission lines due to sand storms and it was during this interval that data contained in his prize winning paper were acquired. He has continued his research work and his thesis in connection with graduate work in physics also has this as a subject. Upon this he will receive his M.A. in August 1932.

G. L. Lillie (A'21) who has received both of the 1931 A.I.E.E. Canada District prizes for best paper and initial paper for his paper "Factors in Design of 115–230-Volt Distribution in a Modern Residential District," is assistant engineer of distribution for the Toronto Hydro-Electric System, Toronto, Canada. He was born at Colbourne, Ontario, Can., and for a while after his graduation from the University of Toronto in 1911, was employed by the Toronto Hydro-Electric System. In October of 1912 he left and for a few months was in the shops of the Westinghouse Company, at Hamilton, Can. He then returned to the University of Toronto for a postgraduate course, and in 1913 was graduated with his degree in electrical engineering. He at once returned to the employ of the Toronto Hydro-Electric System, but in September 1917 left to join the Canadian navy. He received his discharge in January 1919 and again returned to his company, where he has continued to serve to date.

C. A. Church (Enrolled Student) University of Colorado, Boulder, Colo., has been selected to receive jointly with N. R. Damon, coauthor, the 1931 A.I.E.E. North Central District prize for Branch paper. This choice was made based upon the paper entitled "New Ideas for High Voltage Circuit Breakers." Mr. Church was born at Goodell, Iowa. His high school education was obtained at Longmont, Colo., where he was graduated with honors in 1927. As a Fellow at the University of Colorado, he received his B.S. in E.E. there in 1931. At present he is engaged in graduate study and research in electrical engineering at the University of Colorado. This work is supplementary to that by which he earned his M.S. degree June 1932. His fraternal affiliations are Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

W. B. Kouwenhoven (A'06, M'22) vice-president of the Institute for the Middle Eastern District, and professor of electrical engineering and assistant dean of The Johns Hopkins University, Baltimore, Md., has been accorded special honors by those in charge of the International Electrical Congress being held in Paris this month (July 4–12, 1932). Doctor Kouwenhoven in collaboration with Dr. O. R. Langworthy prepared a paper "Injuries Produced by Contact With Electric Circuits" for presentation in Paris, embracing the findings of their original and extensive research work at The Johns Hopkins University. According to a report recently received, "Because of the interesting work of Messrs. Kouwenhoven and Langworthy [the committee] listed their contribution as a report and not as a paper." The significance of this recognition is that the paper will appear as an independent, individual contribution and not as a part of any general report; also the authors are exempt from the payment of membership fees, and in addition will be awarded the sum of 2,000 francs as part payment of expenses for attendance at the congress. (EDITOR'S NOTE: The important findings of Doctor Kouwenhoven's work have been covered from time to time in his contributions to the pages of ELECTRICAL ENGINEERING; others are scheduled for the future.)

L. A. MAGRAW (A'07, M'13) president and general manager of the South Carolina Power Company of Charleston, S. C., at a recent Southeastern Division conference of the National Electrical Light Association was chosen to serve as its president; and J. M. BARRY (A'11) vice-president in charge of operation for the Alabama Power Company, Birmingham, Ala., became the second vice-president of this same division of the N.E.L.A.

R. A. MILLIKAN (M'22) director of the Norman Bridge Laboratory and chairman of the executive council of the California Institute of Technology, Pasadena, Calif., recently was reelected president of the board of directors of the National Advisory Council on Radio in Education. M. I. PUPIN (A'90, F'15, HM'28 and past-president) also received reelection to the vice-presidency of the Council.

S. A. KNIGHT (A'31) who last year was assistant engineer for the Irak Petroleum Company, Ltd., of Manchester, England, with headquarters in Tuz Khurmatu, Province of Irak, recently returned to Great Britain to become assistant technical engineer for the Central England Board, in its North West area. The home office of the board is at Manchester, England.

J. E. E. ROYER (A'15) general manager of The Washington Water Power Company, Spokane, Wash., has been made vice-president as well. Mr. Royer who came to The Washington Water Power Company in 1907, became assistant superintendent of the light and power department in 1919, assistant general manager in 1924, and general manager 2 years ago.

S. P. GRACE (A'03, F'21) assistant vice-president of the Bell Telephone Laboratories, Inc., and well known for his popular lectures on various advances in the science of communication, recently received the degree of Doctor of Engineering from the University of Michigan, and the honorary degree of Doctor of Laws from Notre Dame University.

GEORGE FISKE (A'11) who has been serving the General Electric Company at Kansas City, Mo., as its assistant manager, now has been made manager of the company's office there, it was recently announced. Mr. Fiske joined the company in 1904 as a test man, and barring military service 1917–19, has been continuously with it to date.

G. W. ELMEN (M'21, F'27) telephone engineer for the Bell Telephone Laboratories, Inc., and inventor of the magnetic alloys, permalloy and perminvar, has received the honorary degree of Doctor of Engineering from the University of Nebraska, his alma mater. At the laboratories, Mr. Elmen is in charge of research in magnetic materials.

E. R. HEDRICK (M'25) professor of mathematics and chairman of the department of mathematics at the University of California, Los Angeles, has been awarded the title of "Officier d'Academie" by the French government, "for services rendered to the cause of culture and science."

F. L. KRADEL (A'27) who for some time was sales engineer for The Champion Switch Company of Kenova, W. Va., and subsequently removed to Millvale, Pa., recently became representative for the Royal Electric Manufacturing Company, Chicago, Ill., in its southern Pennsylvania and West Virginia territory.

J. W. MCCARTIN (A'20) previously of the engineering department of E. L. Phillips and Company, New York, N. Y., now is chief operator for the Nassau division of the Long Island Lighting Company, Glenwood Landing, N. Y. His office with the Phillips company was that of power plant and substation designer.

A. H. GFRORER (A'14) for the past 13 years chief engineer of the Automatic Transportation Company of Chicago, Ill., and in addition to these duties, for the past 3 years holding like office with the Barrett Cravens Company, Chicago, Ill., resigned from both of these organizations as of June 30, 1932.

K. W. JOHN (A'29) has resigned his position as chief electrician of the Graham Paige Motors Corporation, Detroit, Mich., and on June 1, 1932 became affiliated with the United States Rubber Company, Detroit, Mich., as technical engineer of its plant in that city.

N. MIRIDJANIAN (A'31) who for the past year or so has been associated with the Columbia Graphophone Company, Istanbul, Turkey, recently established the "Gans" Electroplating Works, which he announces is the first modern electroplating shop in Istanbul.

DICK PYPER (A'29) who in the past has been associated with the Southern California Edison Power House No. 3 at Big Creek, Calif., recently became hydroelectric power house operator of the Turlock Irrigation District, at Turlock, Calif.

W. R. THORSON (A'26) who previously was superintendent of electrical distribution for the Consumers Power Company at Hudson, Mich., recently was made superintendent of public works for the City of Waverly, Iowa.

P. W. BUCHHART (A'32) who in 1931 served the Pennsylvania Railroad Company, Philadelphia, Pa., as draftsman, is now engineer and director of the International Patent Commercialization Company, Inc., New York, N. Y.

W. T. POWELL (A'14) previously patent engineer for the Stromberg-Carlson Telephone Manufacturing Company, Rochester, N. Y., now is serving the General Railway Signal Company, that city, as its patent attorney.

H. K. V. TOMPKINS (M'31) who last year was associated with the Gulf Produce Company, Houston, Texas, now is assistant to the president of George F. Getty, Inc., and Pacific Western Oil Company, Los Angeles, Calif.

R. B. H. ROCKWELL (A'29) previously in the operating engineering department of the Georgia Power Company at Atlanta, Ga., now has been transferred to that company's office at Macon, Ga., as lighting engineer.

J. P. GRABLE (A'22) who heretofore has been identified with the General Cable Corporation, Fort Wayne, Ind., now is coil engineer of the American Enameled Magnet Wire Company at Port Huron, Mich.

ERNEST KAUER (A'25) who in the past has been president of the CeCo Manufacturing Company, Providence, R. I., recently changed to become president of the Molding Corporation of America, of that city.

W. S. LEE (A'04, F'13 and past-president) chief engineer of the Duke Power Company, Charlotte, N. C., recently received the degree of Doctor Laws from The Citadel Military College of South Carolina.

THOMAS PADEN (A'28) formerly superintendent of distribution of the Ohio Edison Company, Youngstown, Ohio, now is electric superintendent of the Pennsylvania Power Company, New Castle, Pa.

C. N. JOHNSON (A'17, M'26) engineering manager of the Westinghouse Electric and Manufacturing Company, Philadelphia, Pa., now has joined the company's forces at 150 Broadway, New York, N. Y.

W. C. SEALEY (A'25) who recently became identified with the Allis-Chalmers Manufacturing Company's office at Milwaukee, Wis., has been transferred to its works at Pittsburgh, Pa.

E. F. MEKELBURG (A'21, M'30) who has been serving Cutler-Hammer, Inc., Milwaukee, Wis., as supervisory engineer, now is identified with the Industrial Controller Company of Milwaukee.

F. W. Pembleton (A'20) formerly winding supervisor of the General Motors Radio Corporation, Dayton, Ohio, now is chief engineer of the Volume Control Service, Fort Wayne, Ind.

L. R. Milburn (A'20, M'31) who was assistant electrical engineer of the Great Lakes Steel Corporation, Detroit, Mich., now is electrical engineer for that same company at Ecorse, Mich.

R. R. Black (A'30) once the General Electric Company's electrical engineer at Fort Wayne, Ind., now is engineer of the Polymet Manufacturing Corporation, New York, N. Y.

C. D. Raymond (A'27) who has been an electrical engineer for the General Electric Company at Newark, N. J., recently joined the Ellenville Electric Company, at Ellenville, N. Y.

C. H. Roth (A'11) who has been president of Roth Brothers and Company, Chicago, Ill., now is president of the Light Sensitive Apparatus Corporation, at Niles Center, Ill.

Herbert Hoover (HM'29) President of the United States, recently received from Gettysburg College, Gettysburg, Pa., *in absentia* the degree of Doctor of Science.

André Mestraud (M'24) of Lanobre, Cantal, France, has recently been made directeur de l'Energie Electrique du Littoral Meditarraneen, at Marseille, France.

# Obituary

Walter Throop Kendall Brown (A'07, M'13) chief of the engineering staff of the Winchester Repeating Arms Company, New Haven, Conn., died at his home at Short Beach, Conn., June 12, 1932. He was born at Paterson, N. J., February 26, 1874, and after obtaining his elementary education in the New York State public schools, entered upon a scientific course at the Williston Seminary at East Hampton, Mass. Thereafter he attended the Cincinnati Art Academy for design and woodcarving; then, returning to the New England section, joined the night school of the Brooks Locomotive Works, well known in the nautical world. Pursuing this bent, he completed a course in ocean navigation with the International Correspondence School, also taking up the subjects of electric railways, lighting and interior wiring, electric transmission, and steam boilers. He then made an exhaustive 3-year study of the deviation of the compass on iron ships. Mr. Brown was at one time chief petty officer in the United States Navy, spending $1^{1}/_{2}$ years in the pay department and $2^{1}/_{2}$ years on construction repair equipment and electrical equipment. He has also served as quartermaster and officer of the U.S. and British Merchant Marine. From 1904 to 1912 he was with the Stanley Electric Manufacturing Company and the General Electric Company's Pittsfield Works, as erecting engineer for central stations, assistant works manager for fire protection, and electric superintendent of maintenance and equipment. In 1912 he became assistant general manager and supervising engineer of the Star Electric Company, subsidiary of the General Electric Company, and as such had charge of checking fire alarms and police telephones; organized and put in a complete manufacturing system, and supervised engineering manufacture and construction. In 1915 he joined his last company, the Winchester Repeating Arms Company of New Haven, as equipment engineer and manufacturing engineer. He was particularly successful in organization work and the training of young engineers.

Besides his Institute connection, Mr. Brown held membership in the Society of Military Engineers, the Spanish War Veterans, the Massachusetts Society, Sons of the American Revolution, and the Crescent Lodge of Masons, Pittsfield, Mass.

John Oliver Montignani (A'06, M'13) who while in New York, N. Y., made the Fraternity Club his headquarters, died of pneumonia at the home of his brother, at Woburn Green Bucks, England, May 12, 1932. Mr. Montignani was born at Edinburgh, Scotland, April 7, 1880. He entered the George Watsons College at Edinburgh in 1887 and in 1895 was graduated from the commercial division. The period 1895–9 was spent in study on electrical subjects, and in conjunction with this academic work he was receiving practical training in the engineering field under a 5 years' indenture with the firm of James Milne and Son, Limited, at Milton House Works, Edinburgh. This course was completed in 1901 and Mr. Montignani undertook a special study of electric railway engineering, coming to the United States in the fall of 1902, to follow up this line of endeavor. Upon arrival here he went to work in the experimental department of the Consolidated Car Heating Company of Albany, N. Y., and until June 1903 was employed in its car lighting system. He then left to enter the employ of the Rochester Railway Company, at Rochester, N. Y., where he was employed as assistant engineer. Four years were spent in the design, supervision, and installation of transmission lines, general overhead construction, and substation equipment; for 4 years more he was engineer of electrical distribution; another 4 years were spent as assistant engineer upon New York State railways. Subsequently he was made division superintendent of the Rochester Railway and Light Company at Rochester, N. Y., and in 1926 became assistant electrical engineer of the Westchester Lighting Company at Yonkers, N. Y., a position which he continued to fill over a period of several years. In 1930 he was made engineer of electrical transmission for Stevens and Wood, Inc., New York, N. Y.

Harold Seaburg (A'24, M'29) chief electrical engineer of the United Fruit Company, Banes Division, Oriente, Cuba, died March 13, 1932, after a week's illness with pneumonia. Mr. Seaburg was a native of Tranas, Sweden (Nov. 27, 1897), and completed both grade school and technical college in an electrical engineering course, at Orebro, Sweden. In 1918 he became a draftsman of the Swedish General Electric Company, at Vesteras, Sweden, and 2 years later took up the duties of assistant electrical engineer in addition to his work as a draftsman with the Star Electric Motor Company at Newark, N. J. In 1922 as draftsman he joined the power division of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and the following year became a draftsman in the engineering department of the New York Edison Company, New York, N. Y. As assistant electrical engineer of the Havana Central Railroad Company, Cuba, he detailed the layout, installation, and operation of the main switchboard equipment in Melones power plant of this company, and in its 3 railway and lighting substations. He also was largely responsible for the installation of the central power plant in the city of Havana, Cuba. As chief electrical engineer of the United Fruit Company, Banes, Oriente, Cuba, he was in charge of all electrical equipment in the electrified sugar central which has a normal annual output of about 700,000 bags.

George Crisson (A'09, M'30) who has been with the American Telephone and Telegraph Company, New York, N. Y., since 1910, died at the Presbyterian Hospital in Newark, N. J., May 22, 1932. Mr. Crisson was born at Astoria, N. Y., October 2, 1885. His M.E. degree was conferred upon him by Stevens Institute of Technology, Hoboken, N. J., to which he returned as an instructor in electrical engineering in 1906. In this capacity he continued until 1910, the year of his joining the American Telephone and Telegraph Company for the design and testing of fittings and structures used in outside plant construction. In 1914 he changed over to development work on transmission problems, principally in the application of telephone repeaters to the improvement of long distance transmission, but including related matters, such as amplifiers for public speaking systems, voice-operated apparatus for the suppression of echoes and singing on long distance wire circuits, the transatlantic radiotelephone circuits, and proposed transatlantic cable. Several patents in this field were the results of work, and were incorporated in the company's communication system and specifically in the dial telephone.

William Franklin Yeager (A'27) engineer of the United Engineers and Constructors, Inc., Philadelphia, Pa., died February 13, 1932. Philadelphia was his place of birth, September 18, 1879; there also he received the major portion of his grade schooling, going later to the Williamson Free School of Mechanical Trades, Williamson, Pa., from which he was graduated as an electrical machinist in 1899; Mr. Yeager's experience in the commercial world was broadly diversified, including much of design, construction, and machine work in other than electrical fields. For H. S. Farquhar, Philadelphia engineer, he did detailed structural and mechanical calculation, and electrical and mechanical investigation of plant equipment at the Jefferson Hospital, Philadelphia, and investigation and report on electrical machinery, testing of generators, indicator tests on engines, and coal and water rating tests on boilers at the Rittenhouse Club, Philadelphia. For Day and Zimmermann, Inc., later the Day and Zimmermann Engineering and Construction Company, he functioned as engineer and chief draftsman, chief structural engineer, and finally consulting engineer, spending 7 years in the company's employ. During the period 1918–1920 as design engineer for Day and Zimmermann his work was the supervision of engineers, under the direction of the Construction Division of the U.S. Army, on the Philadelphia Quartermaster Terminal and the Motor Transport headquarters. The supervision of design for a power plant at McAllister, Okla., also was Mr. Yeager's work, as was the investigation and report on terminal warehousing and motor and rail facilities on Long Island, N. Y. Most of his latter work was investigation and report for his company on development and possible betterment of many large activities.

Harold Bailey Brigham (A'31) engineer of the Byllesby Engineering and Management Corporation, with the Oklahoma Gas and Electric Company, Oklahoma City, Okla., died April 10, 1932 in that city. He was born at Belle Plain, Kans., July 23, 1899, and won his degree of B.S. in E.E. at the University of Oklahoma in 1923. After graduation he joined the distribution engineering department of the Oklahoma Gas and Electric Company, his affiliation with this company representing rapid progress through its various departments; extension engineer in the contracts department; division engineer; back to the distribution engineering department; in the office of the general superintendent; assistant distribution engineer in 1928. That same year he became a member of the Oklahoma City auxiliary force of engineering of the Byllesby Engineering and Management Corporation, the organization with which he was identified at the time of his death.

Thomas McLean (A'11) who for many years served the Los Angeles Gas and Electric Corporation, Los Angeles, Calif.; in varying capacities of operator and as foreman of substation operators, died Friday, May 13, 1932. A native of Long Island, N. Y., Mr. McLean in 1895 at the age of 17 engaged with the Brooklyn Edison Company, Brooklyn, N. Y., starting as a trimmer and advancing to generating station operator, the position which he held until he resigned in 1910. Thence he went directly to Los Angeles and joined the Los Angeles Gas and Electric Corporation. Here he was a meter tester, a work which he continued over a period of years. In 1923 he assumed the title of operator, and a year or so later was made foreman of substation operation.

Henry Worrell Beers (A'25) of the H. W. Beers Company, Mexico, D. F., Mex., died there the 10th of April 1932. Although for years a resident of Mexico and the head of an established electrical supply business there, Mr. Beers was a native of the United States, having been born in Columbus, Miss., December 31, 1876. Before founding his own business, he worked for the Mexican Light and Power Company, Mexico City, over a long period of years.

Jin Tachihara (A'98) manager of the Mitsubishi Electric Company, Tokyo, Japan, and prominent in the engineering profession of that country, died December 16, 1931. At the time of his becoming a member of the A.I.E.E., Mr. Tachihara was affiliated with the General Electric Company of Schenectady, N. Y.

# Local Meetings

## Oklahoma City Section Meets With Branches

The annual joint meeting of the Oklahoma City Section and the student Branches at the Oklahoma A. & M. College and the Univ. of Oklahoma, was held at the latter school on May 16, 1932. Students of the 2 schools presented the following technical papers:

**Morning**

Measurement of Distortion, by J. L. Lisk, Univ. of Okla.

Manufacture and Use of Tungsten Carbide Diamond Substitutes: Electrical and Other Considerations, by G. L. Keyser, Okla. A. & M. Col.

Calculating Tables for Distributed Loads on Transmission and Distribution Circuits, by F. H. Cullison, Univ. of Okla.

Economics of Rural Line Distribution, by B. E. Lowe, Okla. A. & M. Col.

A luncheon was held at the Student Union Building, followed by a short tour of inspection through the various engineering buildings.

**Afternoon**

Voltage Regulating Transformers and Their Application, by C. A. Ludwick, Univ. of Okla.

Jet Wave Rectifiers, by L. S. Cox, Okla. A. & M. Col.

Class B Amplifiers, by J. L. Callahan, Univ. of Okla.

Control of Gyroscope Stabilizers for Prevention of Rolling of Heavy Sea-Going Vessels, by P. O. Bobo, Okla. A. & M. Col.

Prizes for the above papers were awarded as follows:

First prize ($15) Bernard E. Lowe, Oklahoma A. & M. Col.

Second prize ($10) Charles A. Ludwick, Univ. of Okla.

Third prize ($5) Powell O. Bobo, Okla. A. & M. Col.

After the student meeting, the Oklahoma City Section held a short business meeting and the new officers were announced as indicated: E. B. Jennings, chmn.; R. F. Danner, vice-chmn.; C. E. Bathe, secy.-treas. The attendance was 80.

# Past Section Meetings

**Akron**

Banquet. Election of officers: A. P. Regal, chmn.; W. H. Tucker, secy. Human Engineering, by Dean F. E. Ayers, Univ. of Akron. May 10. Att. 47.

**Baltimore**

Electric Shock, by Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres. A.I.E.E. Election of officers: J. Wells, chmn.; L. G. Smith, vice-chmn.; J. L. D. Speer, secy.-treas. May 27. Att. 37.

**Cleveland**

Mystery and Musical Telepathy, by Mr. and Mrs. DeJen. Election of officers: J. M. Smith, chmn.; S. B. Taylor, secy.-treas. May 26. Att. 110.

**Connecticut**

Some Practical Problems in the Operation of High Tension Network Systems, by C. W. Mayott, Connecticut Valley Pwr. Exchange. April 14. Att. 60.

**Dallas**

Finances, by J. E. Owens, Republic Natl. Bank and Trust Co. Election of officers: H. K. Handley, chmn.; W. B. Folline, secy. May 16. Att. 58.

**Denver**

Election of officers: W. D. Hardaway, chmn.; A. W. Ainsworth, vice-chmn.; N. R. Love, secy.-treas. May 5. Att. 14.

Moving pictures presented under the auspices of the Colorado Museum of Natural History. Dinner. June 1. Att. 38.

**Detroit-Ann Arbor**

Adventures in Science, by Oliver Ajer, Genl. Elec. Co. Demonstrations. May 17. Att. 325.

**Erie**

Lighter Than Air Craft, by V. R. Jacobs, Goodyear Tire & Rubber Co. May 17. Att. 175.

**Iowa**

Election of officers: L. F. Wood, chmn.; B. S. Willis, secy.-treas. May 24. Att. 11.

**Kansas City**

Banquet. The Requirements for Business Recovery, by Prof. J. H. Taggart, Univ. of Kansas. Election of officers: G. O. Brown, chmn.; E. W. Harvey, secy.-treas. May 26. Att. 53.

**Lehigh Valley**

Aeroplane and Ship to Shore Communication, by L. Espenschied, American Tel. & Tel. Co. Feb. 12. Att. 104.

Recent Advances in Engineering as Applied to Industry and the Home, by C. K. Lee, Westinghouse Elec. & Mfg. Co. Illus. April 22. Att. 117.

High Voltage Cables—Their Manufacture and Application, by D. M. Simmons, Genl. Cable Corp. Election of officers: J. G. Charest, chmn.; W. A. Skinner, secy. May 13. Att. 90.

**Los Angeles**

Boat trip around the Los Angeles harbor and dinner. May 14. Att. 60.

**Louisville**

New Dial Telephone Equipment, by H. C. Walker, Southern Bell Tel. & Tel. Co. Demonstrations. Inspection of the new telephone building and equipment. May 13. Att. 87.

**Lynn**

Inspection trip of the East Boston Airport of the Curtis-Wright Flying Service. April 23. Att. 300.

**Madison**

Governors and the Governing of Prime Movers, by Albert Kalin, Woodward Governor Co. Inspection trip through the plant of the Woodward Governor Co. May 21. Att. 57.

**Mexico**

Comparison Between Group Drive and Individual Drive in Shops, by L. Castro, Jr., Natl. Railways of Mexico. May 19. Att. 30.

**Milwaukee**

Modern Manchuria, by Prof. H. E. Babbitt, Univ. of Ill. Joint meeting with Engrs. Soc. of Milwaukee. April 20. Att. 300.

Educational Future of the College of Engineering, U. of Wis. by Dean F. E. Turneaure; Reminiscences of an Engineer, by Prof. D. W. Mead; Plan Development for the College of Engineering, by Arthur Peabody; The Need of a Two Year Course in Engineering, by Arthur Simon. F. H. Dorner presented a tablet with pictures donated to the University on the occasion of the dedication of the new mechanical engineering building. Dinner. May 27. Att. 250.

Recent Applications of the Vacuum Tube in Industry, by R. E. Welton, Genl. Elec. Co. Election of officers: W. F. Lent, chmn.; C. D. Brown, secy.-treas. June 1. Att. 60.

**Montana**

Commutation in Generators and Motors Used in Mine Hoists, by A. W. Boyer; Electrical Properties of Hardened Copper, by H. Lambdin and A. J. Hill, students, Montana State Col. Election of officers: J. A. Thaler, chmn.; H. Dale Cline, secy. June 4. Att. 23.

**Nebraska**

The Engineer in Society and Industry, by T. W. McCullough, Omaha Bee News. Joint meeting with Univ. of Nebraska Branch. May 11. Att. 106.

Short talks by Professors Caldwell and Brookman, Univ. of So. Dakota, P. H. Patton, vice-pres. A.I.E.E., and John Gibb, pres. Omaha Engrs.' Club. Joint meeting with Univ. of So. Dakota Branch. May 17. Att. 25.

**New York**

Lighting Requirements for Publishing Operation, by E. Whitehorne, McGraw-Hill Co., Raymond Hood, and Fouilhoux, and D. Wood, Lockwood Greene Engrs., Inc. May 12. Att. 150.

**Niagara Frontier**

Ladies' night. May 20. Att. 75.

**Philadelphia**

Transoceanic Telephony, by H. S. Osborne, Am. Tel. & Tel. Co. Election of officers: Prof. L. Fussell, chmn.; J. L. MacBurney, secy.; E. C. Drew, treas. May 9. Att. 150.

**St. Louis**

General descriptions of the transmission lines from the Bagnell Station were given by L. T. Byers, Stanley Stokes, and H. E. Gove of the Union Elec. Lt. & Pwr. Co., and F. G. Dana and G. W. Couch of Stone & Webster Engg. Corp. May 18. Att. 98.

**Seattle**

The Use of Electricity in the Electrochemical Industry, by L. Supovi, Hooker Electrochemical Co. Election of officers: A. F. Darland, chmn.; G. L. Hoard, vice-chmn.; K. L. Howe, secy.-treas. May 17. Att. 66.

**Sharon**

The Use of Aluminum in the U.S.S. Akron, by G. O. Hoglund, Aluminum Co. of America. Moving pictures. May 31. Att. 95.

**Spokane**

Steam Power Plant Developments Including Mercury Boilers and Turbines, by W. F. Hynes, Genl. Elec. Co. April 22. Att. 38.

**Syracuse**

Steam Electric Power Plants, by I. E. Moultrop, Edison Elec. Ill. Co. of Boston, vice-pres. A.I.E.E. March 7. Att. 38.

International Engineering Congress, by Dr. C. E. Skinner, Westinghouse Elec. & Mfg. Co., pres. A.I.E.E. Joint meeting with Technology Club of Syracuse. May 9. Att. 225.

# Past Branch Meetings

**University of Akron**

The Firestone Power Plant, by W. J. Boyd, student. F. J. Marcinkoski, student, gave a demonstration of resuscitation. Election of officers: F. J. Marcinkoski, chmn.; R. A. Ries, secy. May 13. Att. 10.

**University of Arizona**

The Deion Grid Circuit Breaker, by B. Watkins, student. April 29. Att. 8.

Discussion. April 22. Att. 8.

Film—"Dynamic America." May 6. Att. 27.

Some Thoughts on Technical Education and The Vernier Slot Effect, by Prof. J. C. Clark, counselor. May 13. Att. 8.

Research on Dielectric Losses in Insulating Materials, by F. A. Decker. May 20. Att. 10.

The Colorado River and the Boulder Canyon Dam, by O. H. Polk. Election of officers: Bruce Watkins, chmn.; Jack Jones, vice-chmn.; H. Stewart, secy.-treas. May 26. Att. 8.

**University of Arkansas**

Plotting Magnetic Fields, by H. G. Thomasson, student; The Tesla Coil, by C. L. Mowery, student; Rural Electrification, by H. H. Lewis, student; Rates, by F. L. McDonald, student. May 2. Att. 25.

Carrier Currents, by W. F. Stewart; Long Distance Communication, by L. C. Wasson; Armature Reaction, by W. C. Whitfield; Hydroelectric Dams, by E. E. Cato; Transoceanic Cables, by W. D. Thornberry; Cathode Ray Oscillograph, by R. E. Cope, all students. May 16. Att. 24.

**Brooklyn Polytechnic Institute**

Regenerative Braking on Direct-Current Railways, by Charles Pedersen, student; Use of Thyrite in the Arms of a Wheatstone Bridge, by F. Rae, student; A Brief History of Photoelectricity, by Frank Maloney, student. Election of officers: I. Andreasen, chmn.; H. Hoffman, vice-pres.; Robert Hampshire, secy.; Charles Pedersen, treas. May 18. Att. 39.

**Bucknell University**

Film—"Dynamic America." Lecture on the photoelectric cell. May 17. Att. 125.

**California Institute of Technology**

Transpacific Radio Communication, by F. H. Kroger, R. C. A. Motion pictures. May 24. Att. 35.

**University of California**

Election of officers: Wm. D. Hudgins, chmn.; V. Welge, vice-chmn.; L. R. Rockholt, secy.; H. Lorenzen, treas. April 27. Att. 11.

**University of Cincinnati**

Joint meeting with the Cincinnati Section with papers by students as follows: A Laboratory Arc Furnace, by E. J. Emmerling; Measurement of Modulation, by J. Epstein; Constant Radio Frequency, by A. C. Herweh; Measurement of Radiation, by C. L. Ramsey; An Electric Organ, by W. E. Kock. May 12. Att. 80.

**Clemson Agricultural College**

Inspection trip to the hydroelectric plants of the Georgia Pwr. Co. April 18. Att. 85.

Election of officers: C. P. Walker, chmn.; T. M. Watson, vice-chmn.; W. F. Tribble, secy.-treas. May 12. Att. 20.

**University of Colorado**

A New Method for Measuring Angular Displacements in Synchronous Machines, by L. L. Mundell and W. C. Spear, students. May 18. Att. 35.

**Cornell University**

Teletypewriter Systems, by B. K. Boyce, N. Y. Tel. Co. April 22.

**University of Denver**

Election of officers: Paul Barth, chmn.; F. A. Dow, vice-chmn.; Carl Hedberg, secy.-treas. May 11. Att. 12.

**University of Detroit**

Banquet. History of Electric Lighting in Detroit, by J. W. Bishop, Ford Motor Co. Election of officers: J. A. Schenk, chmn.; A. Manning, vice-chmn.; Ralph Martin, secy.; Frank Belch, treas. June 1. Att. 33.

**Drexel Institute**

The Development of Long and Short Wave Transmitters, by C. E. Keener, student. May 4. Att. 21.

Election of officers: F. P. States, chmn.; R. W. King, vice-chmn.; F. A. Hipple, secy.; F. E. Seaman, treas. May 18. Att. 15.

**Duke University**

Banquet. Election of officers: Tom Garrett, chmn.; John Womack, vice-chmn.; H. W. Atkinson, secy. May 12. Att. 16.

**University of Florida**

Public Address Systems, by George Haug, student; Problems Encountered in Taking a Transmission Line Inventory, by Craig Huffer, student. May 18. Att. 12.

**Georgia School of Technology**

Inspection trip through the Fox Theater. May 2. Att. 29.

Election of officers: F. T. Meiere, chmn.; E. C. Wagner, vice-chmn.; W. W. Ensminger, secy.-treas. May 16. Att. 53.

**Harvard University**

Some Phases of Institute Work, by I. E. Moultrop, Edison Elec. Ill. Co. of Boston, vice-pres. A.I.E.E. Election of officers; F. W. Roberts, chmn.; R. H. Packard, secy.; R. A. Ward, senior rep.; S. Smith, vice-chmn. May 23. Att. 16.

**University of Idaho**

Telephone Service, by Mr. Hadley, Interstate Telephone Co. Banquet. May 3. Att. 25.

Election of officers: H. R. McBirney, chmn.; Wm. Clagett, vice-chmn.; Fred Quist, secy.-treas. May 13. Att. 18.

**University of Illinois**

Election of officers: J. C. Wheeler, chmn.; P. S. Bickenbach, vice-chmn.; D. Bergelis, secy.; H. W. Bieritz, treas. May 11. Att. 19.

Dinner. May 15. Att. 16.

The Inversion of D-C. Into A-C. by Use of the Thyratron, by Dr. Reich. May 17. Att. 60.

**Iowa State College**

Election of officers: Glenn Lyshoj, chmn.; R. Allbright, vice-chmn.; Robert Doonan, secy.; Truman Eppert, treas. May 11. Att. 30.

**Kansas State College**

Conditions in Russia, by C. R. Bradley. Joint meeting with Univ. of Kansas Branch. May 5.

Giant Radio Tubes, by A. C. Hebert, student. May 12. Att. 57.

Airship Mooring Masts, by A. B. Niemoller, student; New Developments in Photoelectric Cells, by D. A. Bly, student. May 12. Att. 30.

Election of officers: S. R. Mudge, pres.; G. D. Ferguson, vice-pres.; B. E. Hammond, recording secy.; J. P. Kesler, treas.; A. E. Paige, marshall. May 19.

**University of Kansas**

Election of officers: R. C. Jackson, chmn.; R. C. Ayres, vice-chmn.; John Doolittle, secy.; Warren Boast, treas. May 19. Att. 36.

**University of Kentucky**

Modern Methods for Oil Well Drilling, by O. T. Koppius. April 27. Att. 36.

**University of Louisville**

Sir Isaac Newton, by Harold Walter, student. Election of officers: C. B. Eldridge, chmn.; H. F. Walter, vice-chmn.; Frank Neuhouser, secy.-treas. May 20. Att. 20.

**Marquette University**

Business meeting. May 5. Att. 25.

**Michigan State College**

Chicago Radio Show, by R. T. Thompson, student. May 10. Att. 17.

**University of Michigan**

Annual banquet. May 26. Att. 43.

**Milwaukee, School of Engineering of**

Some Aspects of the Public Utility Situation in Wisconsin, by G. W. Post, Milwaukee Elec. Ry. and Lt. Co. Illus. May 11. Att. 112.

**University of Missouri**

Election of officers: A. E. Coffman, chmn.; R. C. Cunningham, secy.-treas. May 12. Att. 17.

**Montana State College**

Milestones in Electrical Progress, by Prof. C. F. Bowman. May 19. Att. 66.

Electrical Properties of Hardened Copper, by A. Hill and H. Lambdin, students. May 26. Att. 88.

**University of Nebraska**

Demonstration of telephone equipment by S. P. Grace, vice-pres., Bell Tel. Labs., Inc. May 11. Att. 94.

Helmholtz's Law and Its Application to Television, by R. Brackett. May 18. Att. 12.

**University of Nevada**

Development of a Course of Study in Illumination, by L. G. Gianini, Genl. Elec. Co. March 17. Att. 34.

Election of officers: Milton Murphy, chmn.; Raymond Robinson, vice-chmn.; Harry Dunseath, secy.-treas. April 25. Att. 8.

**Newark College of Engineering**

Electric Ranges, by Prof. A. A. Mims. May 16. Att. 34.

**North Carolina State College**

Subjects for Fall Convention Papers, by J. L. Ponzer, student; General Report on Fall Meetings, by G. E. Ritchie, student. May 17. Att. 26.

**University of North Dakota**

Facsimile Transmission as Used in Navy Radio Sets, by John Gilhooley. May 4. Att. 14.

**University of Notre Dame**

Commercial Engineering or Engineering Economics, by Mr. DeQuine; Relativity, by J. A. Caparo, counselor. Election of officers: F. J. Lennartz, chmn.; Wm. H. Fromm, vice-chmn.; A. V. Alvino, treas.; J. K. Carnes, secy. May 10. Att. 62.

**Ohio University**

Election of officers: J. F. Hoskinson, chmn.; Wm. B. Cooper, vice-chmn.; E. H. Pryor, secy.-treas. May 11. Att. 37.

**Oklahoma A. & M. College**

Business meeting. May 9. Att. 10.

**Oregon State College**

Election of officers: John Mather, pres.; Bob Blasen, vice-pres.; L. Pennell, secy ; G. Manke, treas. May 2. Att. 20.

Development and Progress of Steam Power, by W. F. Hynes, Genl. Elec. Co. Illus. May 5. Att. 47.

A Modern Radio Test Kit, by H. Beckendorf, student; Directional Antennae and Their Operation, by M. Kofoid, student. May 16. Att. 30.

Joint meeting with the Portland Section at which the following papers were presented by students: Steam vs. Electric Drive for Sawmill Operation, by E. A. Buckhorn; A New Wattmeter for Communication Circuits, by K. R. Eldredge; Progress in the Electrical Measurement of Sound Absorption, by F. A. Everest; An Investigation of Field Strength Variations at Broadcast Frequencies, by G. S. Feikert. May 21. Att. 125.

**University of Pittsburgh**

Economic Value of Research, by Mr. Grondahl, Union Switch & Signal Co. May 5. Att. 100.

A New Type of Automobile Tire, by D. E. Trieber, student. May 12. Att. 100.

**Rensselaer Polytechnic Institute**

Development of Teletypewriter Systems, by P. D. Bryan, N. Y. Telephone Co. Election of officers: R. E. McAdam, chmn.; J. J. Korkoss, vice-chmn.; E. W. Knight, secy.-treas. April 19. Att. 305.

**Rose Polytechnic Institute**

Election of officers: J. C. Dalrymple, chmn.; G. T. Lautenschlager, secy. May 25. Att. 17.

**South Dakota State School of Mines**

The Western Union Program, by Mr. Blewitt, Western Union Telegraph Co. May 10. Att. 32.

**University of South Carolina**

Distribtuion of Power in South Carolina, by Senator T. B. Pearce. Banquet. May 5. Att. 30.

Story of the Motor Pump, by W. R. Humphlett; Electrical Therapeutics in Industry, by D. W. Cardwell; Short Wave Radio, by A. W. Obenschain; Some Marvels of the Universe, by W. S. Smith; Baltimore and Ohio Centralizes Traffic Control, by J. D. Martin, all students. May 12. Att. 36.

**University of Southern California**

Mercury Arc Rectifiers, by Mr. Fewcuey, Genl. Elec. Co. May 11. Att. 27.

Election of officers: R. R. Moore, chmn.; H. A. Peterman, vice-chmn.; Mr. Bailey, secy.; H. West, treas. May 18. Att. 33.

The Future of the Engineer, by Carl Heinze, Los Angeles Bureau of Water and Pwr. May 19. Att. 35.

**Southern Methodist University**

Election of officers: Porter Lindsley, Jr., chmn.; M. P. Jones, vice-chmn.; N. K. Read, secy.-treas. May 18. Att. 11.

Social gathering. May 28.

**Texas A. & M. College**

Discussion. May 19. Att. 50.

**University of Texas**

Electric Rates in Texas, by L. M. Curry, student. May 12. Att. 15.

Election of officers: Frank Sperry, pres.; J. R. Cutler, vice-pres.; Wm. Garrett, secy.-treas.; L. Baker, corres. secy. May 14. Att. 15.

**University of Utah**

A Stroboscopic Device for Studying Rotary Motion, by W. S. Nishiyama and K. M. Neilson, students. Demonstrations. May 2[illegible]. Att. 43.

**Virginia Polytechnic Institute**

Life and Works of Thomas A. Edison, by P. H. Cross. Illus. May 12. Att. 46.

**University of Virginia**

Election of officers: T. J. LoCascio, pres.; C. E. Stahl, vice-pres.; G. K. Carter, secy.; J. W. Bowles, treas. May 23. Att. 11.

**University of Washington**

Modern Switchgear Equipment, by K. L. Howe, Westinghouse Elec. & Mfg. Co. Election of officers: W. Ryland Hill, chmn.; Earl Hathaway, vice-chmn.; Archie Adams, secy.-treas. May 12. Att. 14.

Cushman Power Development, by J. V. Congwer, Engr., City of Tacoma. May 19. Att. 31.

**Washington State College**

Discussion. May 13. Att. 9.

Election of officers: Paul Hand, pres.; A. McDougald, vice-pres.; Dick Wilson, secy.; G. Martinson, treas. May 24. Att. 17.

**Washington University**

Election of officers: Mr. Keiser, chmn.; Mr. Mendel, secy.-treas.; Mr. Maull, vice-pres. May 19. Att. 25.

**Worcester Polytechnic Institute**

Testing of High Voltage Transformers, by A. M. Tarbox, Westinghouse Elec. & Mfg. Co. Election of officers: W. E. Bass, chmn.; F. M. Potter, vice-chmn.; C. S. Brewer, secy.; H. A. Hammer, treas. April 25. Att. 32.

# Employment Notes

## Of the Engineering Societies Employment Service

## Men Available

### Construction

FOREMAN OR CHIEF ELECTRICIAN, expert armature winding, motor repairs, and trouble. Install wiring systems for light and power. Extensive practical experience. D-657.

E.E. GRAD., 1927, Univ. of Wis., 30, married, 6 yr. experience in transformer, relay and meter testing, switchboard installations, outdoor substation construction and drafting, industrial pwr. and lighting layouts, inspection, and estimates. Location, Middle West preferred, others considered. D-1071.

GRAD. E.E., 29; 5 yr. supervisory construction, design, estimating and field engg. experience on super-power plants and substations; 4 yr. industrial pwr. plant operation. Electrical construction and maintenance experience; railway electrification construction experience. C-4428.

GRAD. E.E., 1927, single. 3 yr. construction and engg. work on ry. signals, train control, and small power plants. 2 yr. test dept. of large pwr. company. Desires connection with construction, industrial or utility concern or as instructor in mathematics or E.E. subjects. Available at once. Location, immaterial. C-6439.

### Design and Development

E.E. GRAD., 29, single, 5 yr. experience including 6 months testing a-c., d-c. machines, $4^1/_2$ yr. design 5 to 2,000 hp. a-c. and d-c, motors for industrial and special applications. Thoroughly familiar with motor quotations, estimates and applications. Desires position with utility, mfg. or construction firm. Location, U.S. Available immediately. D-944.

DISTRIBUTION ENGR., MFG. ENGR.: E.E. grad., 27, married, 6 yr. experience with large elec. mfg. company, desires position as transformer design engr., mfg. engr., or as elec. engr. for utility or holding company. Available immediately. D-963.

ENGR., electrical-welding: 13 yr. experience design and application resistance welding equip. 4 yr. full charge design and research. Considerable experience on arc welders. Knows shop practise under mass production conditions. Also had wide experience as sales engr. Held 2 positions as sales mgr. and has nation-wide dealer contacts. D-994.

DESIGNING ENGR., E.E. grad., 32, married, 8 yr. experience in designing and selling instrument and dry type distribution transformers. Desires employment with utility or mfg. concern, selling or engg. Available immediately. Location, immaterial. Best references. D-1015.

E.E. GRAD., 28, married, desires position in design and development or teaching. One yr. Westinghouse Student Course; 6 months Westinghouse Design School; $1^1/_2$ yr. design of fractional hp. motors; $2^1/_2$ yr. design of industrial motors. Available at once. Location, U.S. C-5051.

ELEC.-MECH. ENGR., 30, married, college grad. with usual abilities for elec. relay circuits (autom. teleph., control, alarm systems, signaling) resourceful mech. designer on small apparatus, 5 yr. engg. experience. Available immediately. Location, immaterial. C-8373.

E.E. GRAD., 1928, Rensselaer Poly. Inst., 28 yr. single, 4 yr. experience in genl. elec. pwr. plant and substation design and right-of-way and operating budget work with utility. Desires to enter such a field as plant engg. or industrial or economic planning. Available at once. D-1061.

GRAD. E.E., 29, single, 7 yr. experience designing and installing elec. and mech. equip. for large steel company. Highest references. Location, immaterial. Available on short notice. D-1037.

MECH.-ELEC. ENGR., 32, 4 yr. Cornell design instructor; 5 yr. Allis-Chalmers design; liberal shop experience; 5 yr. cooperative apprenticeship. Will consider anything, anywhere, now available. Salary open. D-122.

### Draftsmen

E.E., 1931, 24, married. Experience: Drafting, grad. of 5 months training in large utility, 6 months in utility research dept. Interested in illumination, substation, or distribution. Available at once, and in need of work. Any location. D-1041.

### Executives

MECH. & ELEC. ENGR., grad., married, 20 yr. experience in design, construction, and operation of mill and smelter in the ferrous and nonferrous industries, with excellent record in plant improvement and lowering production costs, desires responsible position with industrial plant engg. firm or sales office. B-7343.

SUPT. ERECTOR, 28, paper mill and printing mchy., experimental and developing automatic mchy., 7 yr., has legal training; executive and management experience, inspecting and auditing, thoroughly familiar with elec. meter lab. Wants any position to prove his capabilities. D-965.

TECH. GRAD., 33, married. Eleven yr. experience covering all branches of elec. measurements in lab. of large mfg. company. Desires position with utility in meter or transmission and distribution dept. Available on short notice. Location in East preferred. D-981.

EXEC. OR CONSULTING ENGR., mech. and elec., 43, American, college education. Past 3 yr. with prominent engg. organization correlating design engg. work for large central station and industrial pwr. plant projects. Previous experience included building, testing, and operating similar plants. Exceptionally broad experience. Available July 1. D-986.

ASSOC. ELEC. ENGR., 38, married, tech. education, 9 yr. with utility as distribution engr., estimating, inspection, underground construction, contact man, developed plans and records division; 6 yr. research and development on protective devices. Available immediately, location, immaterial. C-8958.

ELEC. ENGR., 34. Ten yr. experience covering design, cost estimating and equipment specifications of pwr. plants, copper refineries, indoor, and outdoor substations, transmission lines, and industrial work. Also 1 yr. experience as asst. research with cable company. C-5473.

E.E.—M.E. GRAD., married, 20 yr. experience, desires connection, engr., asst. exec. where efficient use of pwr. and plant is needed; also teaching. Experienced, design of plant; modern design, manufacture, installation of equipment; plant maintenance; electrical, equipment layouts. Special training, experience, metallurgy, concrete, elec. arc welding, building construction, specifications, business mgmt., sales. C-4519.

E.E., 10 yr. experience. Executive ability. Seven yr. operation and maintenance interconnected pwr. system; relay and communication problems; design and installation automatic equipments. Three yr. with large mgmt. company, including 1½ yr. in Mexico on economic studies, generation and transmission projects, and 1½ yr. electrolysis investigations domestic natural gas lines. D-1003.

EXEC. OR ASST., 18 yr. broad experience in utility, mfg., industrial surveys, and mgmt. problems. Through proper application of engg. analysis and principles, can effect economies in operation and control. Capable organizer. Profitable asst. to busy exec. Salary secondary to opportunity. B-9122.

EXEC. ASST. available, 12 yr. utility experience. Grad. E.E., 37. Appraisal work of pwr. plants, substations, transmission and distribution systems, rate investigations covering industrial service, residential and commercial, cost studies, statistical research, operation in plant, equipment and lines. G.E. test course. B-9782.

E.E., married, E.E., M.E. 22 yr. experience, designing, construction pwr. plants, substations, transmission, distribution systems, industrial plants. 3 yr. charge purchasing engg. equip., foreign interests. 3 yr. executive experience charge engg. dept. large utility syndicate. English, German, Russian, Armenian languages. Available immediately. D-84.

GRAD. E.E., 32, 10 yr. experience, of which over one-half was spent with large utility in engg. and supervisory work and the remainder with mfr. of high tension switching equip. as assistant gen mgr. Available on short notice. Location, immaterial. D-745.

ASSOC. A.I.E.E., B.S. in E.E. Iowa State College, 1929, 32, single, worked way through school, 3 yr. Westinghouse insp. and test, including c.c. regulators, c.l. reactors, dimmer reactors, instrument transf., distribution and power transf. a-c. welding outfits, misc. equipment. Interested in supervision, developments, application engineering, rural electrification. References. Location, immaterial. Available immediately. D-1081.

E.E., 33, married, desires position, mfgr. of radio or public address systems, broadcasting station, or carrier dept. of elec. pwr. co. 4 yr. design, construction, operation, testing of equipment for electric pwr. stations. 6 yr. installation, wiring testing radio broadcast, telephone and telegraph repeaters, and carrier equip. Excellent references. D-733.

E.E. wants position. Wide experience in elec. field, engg., mfg., sales, erection and operation of storage batteries. E.E. Grad. from Mass. Inst. of Tech. C-4109.

GRAD. ENGR., 35, with 10 yr. experience in the engg., operating, and executive depts. of a utility, desires position as jr. exec. or office mgr. in a mfg. concern or utility. Speaks Spanish and has fair knowledge of acctg. B-2470.

### Instruction

GRAD. E.E., 35, married, B.S. in E.E. at M.I.T. 1920. Entire experience since then in E.E. teaching and E.E. industrial work. Good ability and personality. Desires work in E.E. teaching. Salary open. C-2826.

E.E. GRAD., 1925, Ohio State, 32, married, experience; pwr. plant and substation operation and maintenance, distribution (a-c. and d-c.), relay engg., pwr. plant and substation design and supervisory construction experience with contractor, high school instructor. Desires position with future. Available immediately. D-996.

E.E. GRAD., 26, single, desires position in design and development or teaching. Westinghouse student course. Westinghouse design school. Rectifier design. Available at once. Location, immaterial. D-988.

E.E. DESIGNER, 31, married, 4 yr. experience in construction, 3 yr. experience in design of pwr. stations, substations and industrial control, 1 yr. instructor in large univ. and 8 months Westinghouse test course, desires position in engg. office, field construction or teaching. C-5734.

GRAD. E.E., 1926, single, 29, G.E. Test Course, 5 yr. experience on proposition work and specifications as commercial engr. with large elec. manufacturing concern. Desires to enter teaching field in U.S. Electrical subjects, physics, mathematics, or English. Will be interested in opportunity for advanced study. D-1005.

INSTRUCTOR OR ASST. PROF., 38, 8 yr. instructor in E.E., radio, physics in univ.; 5 yr. commercial experience, lighting, pwr., and radio installations, research and design. At present research assoc. in physics in post grad. school of well known univ. Available for next September. C-6302.

DOCTOR OF ENGG., J.H.U., '32, 23, single. Research experience in fields of radio, a-c. and d-c. measurements and high voltage insulation studies. Desires research or engg. position, also teaching in E.E., mathematics, or physics. Location, immaterial. D-1040.

ASSOC. PROF. E.E. B.S., and E.E. deg., 42. 5 yr. teaching experience, 11 yr. design, engg. and exec. experience in radio and communication. Highest references. Available immediately. Location, immaterial. D-1062.

M.S. in E.E. and PHYSICS, 31, married, coached mathematics, physics, E.E. while undergraduate, senior math. asst., some teaching with grad. study. 6 yr. industrial motor design, research, also mfg. practise, motor control. Desires to teach E.E. primarily, charge or part charge of research; can also teach drafting, machine design. Available season 1932–33. D-980.

### Junior Engineers

E. E. GRAD., Purdue, 1931, single, 24. Seven months in training course of a large utility company. Experienced in stenographic and secretarial work. Desires position with future in mfg. concern or utility. Available at once. Location immaterial. D-437.

RECENT COLUMBIA UNIV. GRAD., B.S., 1931, E.E. in 1932; Italian born, but American citizen, desires engg. or teaching opportunity. D-894.

E.E. GRAD., 1928. Iowa State Coll., 25, single. 1½ yr. experience designing of rural lines, 1 yr. experience designing distribution city lines, 1 yr. experience handling joint contracts between elec. and telephone companies. Desires position with utility. Location, Middle West or West. Available immediately. D-978.

JUNIOR ENGR., E.E. GRAD., 31, married, B.S. 5 yr. operating and maintenance utility, 14 months Westinghouse test, 2 yr. Westinghouse motor sales dept. Good experience on motors and control. Some civil engg. experience. D-1025-321-C-2-San Francisco.

E.E. GRAD., '23, Sc.M., M.I.T. and Harvard '28; Sc.D. M.I.T. June '32, thesis in network synthesis; 38, single; 8 yr. practical experience, pwr.-business-and communication engg. Two yr. testing course. Speaks Swedish, English, German; reading knowledge French. Desires position preferably in line of communication engg. Available June 15th. Location, immaterial. D-747.

E.E. GRAD., 27, married. Design of pwr. plant, substation and pwr. transmission lines. Industrial remote control. Also broad experience on appraisals of utilities. Available immediately. Location, immaterial. D-679.

E.E. GRAD., 1932, Univ. of Nebraska, single, 22. Desires engg. work in commercial field. Available now. Location, immaterial. D-997.

MECH.-ELEC. ENGR., 1930 tech. grad., 2 yr. engg. experience manufacture of elec. wires and cables, machine shop work, also surveying and drafting work. Will consider any job or position offered. Available immediately, anywhere, at minimum living salary. Single, 26, and in need of work. D-66.

GRAD. E.E., 1929, single, 23. Fifteen months student engr. on G.E. test. Some test, drafting and switchboard construction experience before graduation. Interested in position with firm doing consulting or construction work or with utility or manufacturer. Available at once. Location, anywhere in U.S., but New England preferred. C-8028.

1931 GRAD., B.E.E. cooperative course, 25, single. Experience includes elec. maintenance, const., drafting, and laboratory work. Location, immaterial. Available at once. D-1060.

EXECUTIVES If you can possibly use an ambitious young E.E. with a B.S. from Brown Univ. who, together with tech. knowledge, combines a knack for managing and publication work your correspondence is requested. The very best references can be furnished. D-742.

RECENT M.I.T. GRAD. (S.B., S.M.), in E.E. 28, cooperative training with Stone and Webster Inc., desires opportunity with future in production or construction field. Previous business experience. D-1047.

B.S. in E.E., 1931, Armour Tech., 23, single, experience: 6 months telephone, 3 months G.E. student, 7 months utility student, speaks German well, wants work, salary secondary, location, immaterial. D-1072.

1931 GRAD. IN E.E., B.S. from Clemson Agril. College, 25, single. Desires work with utility,

## ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
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205 West Wacker Drive
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31 West 39th St.
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MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

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mfg. concern or construction corporation. Available immediately. Location, immaterial. D-400.

E.E. GRAD., Purdue, 1930. Single, 24. 2 yr. communication experience and training with Am. Tel. & Tel. Co., including outside line and cable construction; test room operation, carrier systems, etc., also Morse telegraphy. Not afraid of hard work. References gladly furnished. Available immediately to go anywhere. D-1075.

E.E. GRAD., 26, single, excellent physical condition. One yr. experience installation, testing telephone exchange equipment. Three yr. teaching public school. Graduate small business col. Considerable training, experience, selling. Not afraid of hard work. Interested in position requiring engineering knowledge or teaching experience. Excellent references. Correspondence invited. Location, immaterial. Available immediately. D-1076.

E.E. GRAD., B.S. in E.E., cooperative course, Drexel Inst., 1931. M.S. in E.E., M.I.T., 1932, 23, single. Two yr. experience in plant dept. of Bell Telephone Co. of Pa. Desires engg. or teaching position. Location in East preferred. Available immediately. References upon request. D-1087.

Maintenance and Operation

CONSTRUCTION AND MAINTENANCE SUPT., 37, married. Grad. E.E. Thirteen yr. experience in utility field, particularly in engg., construction and maintenance of distribution and transmission substations. Desires position with large utility with responsibility for the construction, operation, and maintenance of substations. B-2885.

E.E., 31, married, tech. school. Eleven yr. experience, C.G.E. Test 4 yr. Service-maintenance - operation - construction - hydro elec. plants, paper mill-municipal and public utility hydro-plants. Will go anywhere in Canada. D-982.

PRACTICAL ELEC. CONSTRUCTION CHIEF, 32, 14 yr. experience in elec. construction work and also maintenance work. Last 4 yr. in Latin-America. Can speak Spanish and German well. Available immediately. Location, immaterial. C-2101.

E.E. GRAD., married, 8 yr. steam plant operation and maintenance, and factory maintenance. Now unemployed. Location preferred, Middle West or Western. C-8522.

Research

DEVELOPMENT-RESEARCH ENGR., experienced in the design of apparatus in the development of railroad signaling, automatic train control, and centralized traffic control systems, telephone and telegraph systems for commercial use and in connection with train dispatching. Also in making mathematical studies and theoretical investigations. D-995.

MEASUREMENT AND CONTROL SPECIALIST seeks connection with commercial lab., utility or mfr., in capacity of developing or investigating engr. or consultant. Wide and extensive experience with all types of elec. instruments, precision measurement, standardization, and automatic control. Also experienced in pyrometry and pneumatic control. B-7245.

E.E. GRAD., Carnegie Inst. 1921. Graduate work, Carnegie Inst., Univ. of Pittsburgh, 34, married. Experience, telephone switchboard installation, railway appraisal, power plant operation. Two yr. general development lab., Western Elec. Co. Nine yr. research dept., Union Switch & Signal Company doing development work on train control, copper oxide rectifiers. Location preferred, Pittsburgh. D-1031.

Sales

SALES ENGR., grad. E.E. with excellent background of both sales and advertising, desires connection with mfr. Location, Middle West preferred. Experience in industrial advertising in addition to engineering and selling of elec. equip. Excellent references. Age 33, married. B-8614.

SALES ENGR., 40, tech. grad., single, 20 yr. experience selling elec. equip. for industrial plants including utility affiliation involving the sale of central station service to industrial plants and supervising the activities of industrial pwr. salesman. Desires permanent connection preferably as representative of mfr. in an industrial center. C-5546.

E.E. GRAD., 1931, southern univ., married, 21, experience: sales engr., radio service, public address systems, production work location, and estimates. College major hydroelectric systems and transmission. Desires position in above field, especially sound engr. or location work. U.S. or foreign location. D-983.

PWR. SALES ENGR., E.E. grad., 1928, 25, married. One yr. Westinghouse Test Course, 3 yr. with large engg. corporation; pwr. plant and substation design and layout, contact man with elec. mfrs., extensive industrial engg. Desires permanent position as pwr. sales engr. or other engg. work. Excellent references, location, immaterial. C-4303.

E.E., 27, single, 28 graduate. Fifteen months G.E. Test. Two yr. sales experience with elec. servicing concern. Desires position with utility or mfg. concern. Has following with all eastern utilities. Eastern location advantageous. D-974.

ENGR., E.E.-Mech. grad. Yale Univ., 39, married. Eighteen yr. experience on machine tools, G.E. Test and engg. application, sales and sales promotion of elec. equipment. Qualified engr. for research and marketing, also application engr. for elec. and mech. equipment. Available immediately. Location preferred, New York Territory. D-1074.

SALES ENGR., 30, single, E.E. grad. of a reputable 1 yr. engr. school. Five yr. experience selling industrial and central station instruments. Desires position as salesman with a high grade mfg. concern. No particular line desired. Will travel, location, immaterial. C-1570.

# Membership

## Recommended for Transfer

The board of examiners, at its meeting of June 15, 1932, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed with the acting national secretary at once.

### To Grade of Fellow

Gay, Frazer W., asst. engr., United Engineers & Constructors, Inc., Newark, N. J.

### To Grade of Member

Allen, R. W., distribution engr., Narragansett Elec. Co., Providence, R. I.
Carrick, John F. C., sales agent, Genl. Elec. Co., Niagara Falls, N. Y.
Chetham-Strode, A., station design engr., Dallas Pwr. & Lt. Co., Texas.
Coover, Mervin S., prof. of elec. engg., Univ. of Colo., Boulder.
Hamburger, Ferdinand, Jr., instructor, Johns Hopkins Univ., Baltimore, Md.
Harrison, S. H., supt., Vulcanite Portland Cement Co., Phillipsburg, N. J.
Ketchum, Wm. D., engr., Commonwealth & Southern Corp. of N. Y., Birmingham, Ala.
Konn, Felix, design section, motor division, Genl. Elec. Co., Erie, Pa.
Lambert, Alexander B., elec. engr., Crompton Parkinson, Ltd., Toronto, Ont., Can.
Laurtizen, Carl W., asst. prof. of elec. engg., Valparaiso Univ., Ind.
McFarland, T. C., assoc. prof. of elec. engg., Univ. of Calif., Berkeley.
Morecock, Earl M., coordinator of elec. students Rochester Athenaeum & Mechanics Institute, N. Y.
Penniman, A. L., Supt. of steam stations, Consolidated Gas, Elec. Lt. & Pwr. Co., Baltimore, Md.
Price, John R., prof. of elec. engg., Univ. of Wisconsin, Madison.
Rice, Harold F., asst. prof. of elec. engg., Univ. of No. Dakota, Grand Forks.
Robertson, Burtis L., asst. prof. of elec. engg., Univ. of Calif., Berkeley.
Skolfield, Wm. K., designing engr., Genl. Elec. Co., Bridgeport, Conn.
Stover, James R., elec. engr., W. S. Barstow & Co., Inc., Reading, Pa.
Wilson, Henry E., relay engr., Carolina Pwr. & Lt. Co., Raleigh, N. C.

## Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the acting national secretary before July 31, 1932.

Boland, W. I., 801 Sutter St., San Francisco, Calif.
Bottimer, G. W., Consumers Pwr. Co., Grand Rapids, Mich.
Bowman, J. H., Purdue Univ., Lafayette, Ind.
Burckmyer, L. A., Jr., Cornell Univ., Ithaca, N. Y.
Cohn, D. E., R. R. Commission of South Carolina, Columbia.
Cook, I. M., Shell Oil Co., Los Angeles, Calif.
Crum, E. R., Crum Elec. Co., Memphis, Tenn.
Davenport, L. B., Houston Armature Wks., Texas.
Dockendorf, J. P., Airways Radio Sta.. U.S. Dept. of Commerce, Sweetwater, Texas.
Geyer, P. W., Lackawanna & Western R. R. Co., Hoboken, N. J.
Hucks, George J., Pacific Tel. & Tel. Co., San Francisco, Calif.
Kajiura, K., Japanese Gov. Ry., N. Y. City.
Lambert, J. L., Tooke Bros., Montreal, Que., Can.
Maier, J., 1830 2nd Ave., N. Y. City.
Manucia, J. H., Manhattan Elec. & Radio Corp., N. Y. City
Meinders, J. J., New York Edison Co., N. Y. City.
Neubacher, L. L., Pacific Gas & Elec. Co., San Francisco, Calif.
Noble, D. E., Conn. Agri. Col., Storrs.
Nye, E. C., (Member), Instrument Serv. Labs., St. Louis, Mo.
Powell, C. A., 816 Blvd., Westfield, N. J.
Sholl, R. R. (Member), N. Y. & Queens Elec. Lt. & Pwr. Co., Flushing, N. Y.
Skvorzoff, M., 200 W. 111th St., N. Y. City.
Trueblood, R. O., Univ. of Wyoming, Laramie.
23 Domestic

### Foreign

Ali, S. N., H. H. Gov., Patiala State, Punjab, India
Beljavsky, A. G. (Member). North-Caucas Inst. of Energetics, Novocherkassk, U.S.S.R.
Bryant, A., Kenya & Uganda Governments, Nairobi, Kenya Colony, E. Africa.
Chan, S., 33 Wan Tsai Rd., Hong Kong, China.
Crisp, H. K., Municipalities of Bowral and Mittagong and Shire of Nattai Bowral, New South Wales, Australia.
Gokli, K. N., R. Gokli & Co., Matunga, Bombay, India.
Gomez, A., Chilean State Rys., Valparaiso, Chile, So. Am.
Headland, H., Public Wks. Dept., Waitaki Hydro, South Island, N. Z.
Hickey, M. G., Hackbridge Elec. Construction Co., Hersham, Walton-on-Thames, Surrey, Eng.
Perry, A. M., Hachbridge Elec. Construction Co., Surrey, Eng.
Sawhney, B., Assoc. Electrical Industries, Lahore, India.
Thampan, K. C., Pykara Construction Wks., Glen Morgan P. O., The Nilgiris, So. India
Verma, R. P., Gaya Engineering & Elec. Pwr Supply Co., Ltd., Gaya, India.
13 Foreign

# Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Archbold, Earl J., Box 2641, Birmingham, Ala.
Blugerman, L. N., 227 N. 18th St., Phila., Pa.
Bugg, Vernon, 736 Transp. Bldg., Washington, D. C.
Callen, R. J., Brunswick Recording Lab., 799 7th Ave., N. Y. City.
Iwe, Halfdan G., 229 Ovington Ave., Bklyn., N. Y.
Palit, Hari-Charan, 151 Ganesh Mohal, Benare City, India.
Pearson, Ernest, 209 Brewster Rd., Scarsdale, N. Y.
Rogge, C. A., Consumers Pwr. Bldg., Jackson. Mich.
Scanlon, D. L., KFPW, Ft. Smith, Ark.
Schwartz, Carl, 410 Cathedral Pkwy., N. Y. City.
Thomas, Earl Mead, Intl. Genl. Elec. Co., Schenectady, N. Y.
Titland, Trygve T., 1019 Stanton Ave., Elizabeth, N. J.
Van Ness, L. G., 2105–6 Sterick Bldg., Memphis, Tenn.
Vetri, L., Western Elec. Co., Inc., 100 Central Ave., Kearny, N. J.

# Engineering Literature

## New Books
### in the Societies Library

Among the new books received at the Engineering Societies Library, New York, during May are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no reponsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

GALVANISCHE ELEMENTE UND AKKUMULATOREN. By C. Drucker and A. Finkelstein. Leipzig, Akademische Verlagagesellschaft, 1932. 425 p., illus., 10x7 in., cloth, 36 rm.—Intended for the manufacturer of dry cells and storage batteries who wishes an account of the fundamental theory as a basis for research work, and is also interested in a discussion of methods of manufacture. Raw materials, methods of construction, uses, and properties of dry cells and accumulators, are described in a practical way. One-third of the book is an extensive index to German, British, and American patents since 1910.

GASOLINE AUTOMOBILE. By B. G. Elliott and E. L. Consoliver, 4 ed. N. Y. and Lond., McGraw-Hill Book Co., 1932. 605 p., illus., 9x6 in., cloth, $3.00.—The fundamentals of automobile construction, maintenance, and operation are set forth in this work with sufficient fulness for the needs of the owner, operator, repair man, and student. The text is clear and explicit and amply illustrated with photographs and drawings. The revision has been thorough and complete.

HANDBOOK OF THE COLLECTIONS ILLUSTRATING LAND TRANSPORT. III, Railway Locomotives and Rolling Stock. Part 1. Historical Review. By E. A. Forward. London. South Kensington Science Museum, 1931. 99 p., illus., 10x6 in., paper, 2s6d.—This pamphlet provides a very useful, concise review of the development of the locomotive and the railroad car in the British Isles. The locomotive occupies most of the space, and its evolution is expertly traced from Trevithick's experiments in 1801 to the latest types. Electric and internal combustion engines are included.

KOLLOIDCHEMISCHE TECHNOLOGIE. By R. E. Liesegang, 2nd ed. Dresden and Leipzig, Theodor Steinkopff, 1932. 1085 p., illus., 11x7 in., paper, 68 rm., cloth, 72 rm.—An extensive review of practical applications of colloid chemistry, in the form of essays by a number of specialists. The subjects considered include among others lubricants, textiles, rayon, paper, plastics, electrical insulating materials, Portland cement, water, sewage, petroleum emulsions, metallurgy, and flotation. The articles are concise and up to date and contain numerous references to sources. A useful survey of its subject.

HIGH-SPEED DIESEL ENGINES. By P. M. Heldt. Phila., P. M. Heldt, 1932. 312 p., 9x6 in., cloth, $4.00.—Although there is a number of books on Diesel engines, this is the first American treatise specifically for the high-speed oil engine for automotive use. It aims to give an orderly condensed review of the research work done in America and Europe on problems connected with design, with descriptive data and illustrations of typical examples of the various sub-classes. The book brings together an amount of material of interest to designers and experimenters, especially for automobile and aircraft engines, which heretofore has been widely scattered.

NORMALISATIONS, SPÈCIFICATIONS ET PRESCRIPTIONS TECHNIQUES, 1930–31. Union des Syndicats de l'Électricité, Paris, 1931. 1024 p., 9x6 in., cloth, 50 fr.—A collection of rules and standards governing the construction, erection, and operation of electrical equipment as in force in France. Includes standards of the International Electrotechnical Commission, the French Electrotechnical Commission, the Union des Syndicats de l'Électricité, and other associations of engineers and manufacturers, and of government agencies. Convenient and comprehensive.

PRINCIPLES OF PUBLIC UTILITIES. By E. Jones and T. C. Bigham. N. Y., Macmillan Co., 1931. 799 p., 9x6 in., cloth, $4.25.—A text on the economics of public utilities, a text-book for students and a manual for officials, engineers, and others interested in public utility problems. The discussion is confined to the utilities supplying electric light and power, gas, street railway service, telephone service, and water. The subjects treated include regulation, valuation, rates, finances, combinations, public ownership, and other outstanding problems.

TABLES ANNUELLES DE CONSTANTES ET DONNEÉS NUMÉRIQUES DE CHIMIE, de Physique, de Biologie et de Technologie, 1929, v. 9. Paris, Gauthier-Villars et Cie; N. Y., McGraw-Hill Book Co., 1931. 1607 p., 11x9 in., cloth, $12.00.—With this issue this important reference work is again upon an annual basis. The present volume contains all the constants and numerical data published during 1929 in the fields of chemistry, physics, biology, and engineering. The series is an indispensable supplement to the "International Critical Tables" and is essential to every research worker. Text in both English and French.

TRANSFORMATEURS DE MESURE ET RELAIS DE PROTECTION. By C. Bresson. Paris, Dunod, 1932. 293 p., illus., 10x6 in., cloth, 91 fr.—Two important questions in distribution systems are discussed. The first half discusses the characteristics of instrument transformers, the qualities that effect their efficiency, and their use in distribution systems. The remainder of the book describes the principal types of circuit breakers and protective relays and illustrates their uses.

ÜBER DEN SCHALLSCHUTZ DURCH BAUKONSTRUKTIONSTEILE. (Beihefte zum Gesundheits-Ingenieur, Reihe 2, Heft 11.) By H. Reiher. München and Berlin, R. Oldenbourg, 1932. 28 p., 12x9 in., paper, 4.80 rm.—By tests in laboratory and buildings the soundproofing properties of over 200 old and new structural elements were determined accurately. The results are presented in tables, accompanied by an account of the theory of sound propagation and of transmission, and a description of the methods of measurement used in this investigation. General conclusions are drawn from the tests and minimum requirements suggested.

AIRCRAFT YEAR BOOK, v. 14, 1932. By Aeronautical Chamber of Commerce. N. Y., D. Van Nostrand Co., 1932. 626 p., illus., 9x6 in., cloth, $6.00.—Part I records outstanding events of the year's aviation, American and elsewhere; part II deals with engineering and manufacturing progress and illustrates American aircraft and engines; part III is a chronology of important contests and records. The remainder gives useful statistics and directory of officials, associations, etc. A convenient summary of all matters of aviation.

AM. SOC. FOR TESTING MATLS. INDEX TO PROCEEDINGS, v. 26–30, 1926–30. Phila., A.S.T.M., 1932. 251 p., 9x6 in., to members, cloth, $1.75; half leather $2.75; non-members (cloth $2.50, half leather, $3.50.—A full subject and authors' index to these proceedings of the society, for testing materials and the study of their properties. A supplement to the first 25 vols.

BARRAGES CONJUGUÉS ET INSTALLATIONS DE POMPAGE. By G. Laporte. Paris, Gauthier-Villars et Cie, 1932. 144 p., 10x7 in., paper, 35 frs.—An investigation of economic possibilities of increasing hydroelectric output by pumping water back to reservoirs with off-peak power; especially suitable where 2 or more plants upon 1 river are operated together. Feasible plans of pumping are discussed, and plant characteristics suited to each determined.

BIBLIOGRAPHY OF AERONAUTICS, 1930. Natl. Advisory Comm. for Aeronautics. Washington, D. C., U. S. Govt. Prtg. Office, 1932. 261 p., 10x7 in., paper, $0.50.—1930 literature including references to articles in principal world magazines. Alphabetized with authors and subjects in one listing. A continuation of a series which covers the subject from early times.

COLLOID CHEMISTRY, v. 4. Ed. by J. Alexander. N. Y., Chem. Catalog Co., 1932. 734 p., illus., 9x6 in., cloth, $11.50.—Concludes a series of valuable papers published by Dr. Alexander during past 6 years. Devoted to technological applications and items on colloid chemistry of cellulose, paper, explosives, sugar, and other carbohydrates; dyeing; rubber; plastics; tanning; paints; electroplates, etc.; solidified alcohol; fire extinguishers; water supply and sewage disposal.

DIELECTRIC. III. BREAKDOWN OF SOLID DIELECTRICS. By S. Whitehead, ed. by E. B. Wedmore. London, Ernest Benn, 1932. 346 p., illus., 9x6 in., leather, 30s.—This completes the survey of dielectric phenomena prepared by the British Elec. and Allied Industries Research Board. Is a critical summary of information available on dielectric phenomena with particular reference to the theoretical basis and failure of insulation in service. Includes bibliography.

EARTH DAM PROJECTS. By J. D. Justin. N. Y., John Wiley & Sons, 1932. 345 p., illus., 9x6 in., cloth, $5.00.—An endeavor to set forth the principles of design and construction useful to the engineer, illustrating applications by concrete examples. It opens with description of dam failures and the causes, treating of preliminary investigations and surveys, subsurface investigations, and materials and laboratory tests. Problems of design and construction are given in detail and various methods of building described. Ends with description of a number of representative dams. As the only such work in print, it fills a distinct need.

EINFÜHRUNG IN DIE THEORETISCHE ELEKTROTECHNIK. By K. Küpfmüller. Berlin, J. Springer, 1932. 285 p., illus., 10x7 in., cloth, 19.50 rm.—An introduction to elec. engg. theory intended to fill a field between elementary text and treatises upon specific applications. Confined to facts and methods required as a general background by the engineer interested in development of electricity. Holding to essential physical laws makes thoroughness possible in a book of moderate size.

ELEKTROTECHNISCHE GESELLSCHAFT, Frankfurt am Main, 1881–1931. Geschichtstafeln der Electrotechnik. Collected by S. Ruppel. Berlin-Charlottenburg, Verband Deuts. Elektrotechniker, 1932. 127 p., illus., 12x8 in., paper, 6 rm.—A memorial volume for the 50th anniversary of the Elect. Engg. Soc. of Frankfurt. A series of interesting tables of outstanding dates and developments on theoretical principles, generators, motors, machine tools, railroads, transmission lines, insulators, cables, switch-gear, power plants, lighting, storage batteries, meters, telephony, radio, etc. Statistics also are given showing the growth of industry.

ELEMENTS OF ELECTRICAL DESIGN. By A. Still. 2 ed., N. Y. and Lond., McGraw-Hill Book Co., 1932. 583 p., illus., 9x6 in., cloth, $5.00.—Presenting the elements of electrical design. Not to train designers, but to give students an understanding of fundamental principles in application to concrete designs. A new edition revised thoroughly for the trend toward higher operating voltages and improved efficiency.

FARADAY AND MAXWELL. (Deutsches Museum Abhandlungen und Berichte, Jahrg. 4, Heft 1.) By E. Cohn. Berlin, V.D.I.-Verlag, 1932, 29 p., illus., 8x6 in., paper, 90 rm.—An essay linking the lives and work of Maxwell and Faraday in a most interesting way, and showing how our present principle of energy through Maxwell's studies was evolved from Faraday's experiments.

GESCHLICHTLICHE EINZELDARSTELLUNGEN AUS DER ELEKTROTECHNIK, v. 3. By Elektrotech. Verein. Berlin, J. Springer, 1932, 125 p., illus., 9x6 in., cloth, $2.64.—Three interesting papers in a new volume of a series. Dr. Weicker gives a history of the development of insulators for overhead lines; Dr. Fischinger the early history of the Lauchhammer power plant, the first 100-kv. plant in Europe; and Dr. Poschenrieder gives interesting recollections of his experiences in the infancy of elec. engg.

ILLUSTRIERTE TECHNISCHE WÖRTERBÜCHER, Deutsch, Englisch, Französisch, Italienisch, v. 17. AERONAUTICS. Ed. by A. Schlomann. Berlin, V.D.I.-Verlag, 1932. 740 p., 10x7 in., cloth, 30 rm.—This volume follows the general plan of the series to which it belongs, with about 13,000 terms being arranged systematically; indexes in German, French, Italian, and English. Illustrated freely. Prepared with the assistance of a number of engg. soc. and firms, aviation boards, and govt. bureaus. Claimed superior to any dictionary available and welcome to translators.

### Engineering Societies Library

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MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

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A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

# Industrial Notes

**Electric Heat Speeds Plant Growth.**—Electric heat furnished by General Electric soil-heating equipment during the 1931–1932 season helped improve the quality of farm products, aided in getting them to market earlier, helped growers to a profit, and gave power companies an additional annual consumption of one and a half million kilowatt-hours of electric current, declared G. A. Rietz, in charge of the rural electrification section of the company, in a recent talk before rural electrification specialists of the Niagara-Hudson Power Company. The equipment, including cable and thermostats, was sold to farmers throughout the United States on an active commercial basis for the first time last season. The bulk of the power is used between sundown and sunrise, making it practically an offpeak load.

On the strength of sales activity in cooperation with central station representatives, and the testimony of thoroughly beneficial results, the demand for electric hot-bed equipment is expected to more than treble the kilowatt-hour load for the next growing season. "This estimate is based on the enthusiastic acceptance and adoption this past season, the present demands for the coming season, and the reports made on results by commercial growers. All these indications point to an additional 5,000,000 kilowatt-hours in annual consumption during the coming season by reason of new installations of this heating equipment," Mr. Rietz said.

**A New Insulation.**—A new chemical product which has practically all of the characteristics of rubber, but which is not affected by solvents, has been in commerical production for some time past. It is an olefin polysulfide reaction product known as Thiokol, and is manufactured by The Thiokol Corporation, Yardville, N. J. This product is made entirely of chemicals through a simple process and like rubber it is compounded and vulcanized in the processing of finished articles. Unlike rubber, Thiokol compounds do not age or perish in storage. Oxygen does not appear to affect it and the ozone generated during electrical corona tests does not cause deterioration. A number of leading electrical manufacturers are said to be testing Thiokol at present for use in the following applications: protective covering for underground low voltage cable; connections for oil filled cables in place of cement; submarine cables; ignition cables to protect against oils and corona conditions; transformer gaskets, high voltage cable covering in place of lead, and others.

**New Tachometer.**—A new direct-reading hand tachometer for testing r.p.m. machine speeds has been developed by the Amthor Testing Instrument Co., Inc., 309 Johnson St., Brooklyn, N. Y. It incorporates the new feature of automatic fixed reading whereby speed readings are automatically fixed on the dial after use. The dial reads directly in r.p.m., but all accessories are included so that "feet per minute" surface belt speeds can be taken. Various ranges can be had to directly measure speeds as high as 12,000 r.p.m.

**U. S. Magnetic Products Corp. Elects M. B. Mervis.**—According to a recent announcement, M. B. Mervis, formerly secretary-treasurer and general manager of the American Insulated Wire & Cable Company, has been elected chairman of the board of the U. S. Magnetic Products Corp., Chicago and Lock Haven, Pa. Manufacturing facilities are being augmented by the addition of more modern machinery for coil winding and for manufacturing electromagnets, solenoids, various types of small transformers, and magnetic specialties.

# Trade Literature

**Lightning Arresters.**—Bulletin GEA-93H, 16 pp. Describes G-E lightning arresters for pole mounting, pellet type and compression-chamber types. General Electric Co., Schenectady, N. Y.

**Lugs.**—Bulletin, 10 pp. Describes a complete line of copper soldering lugs. Ilsco Copper Tube & Products, Inc., 5629 Madison Road, Cincinnati, Ohio.

**Graphic Meters.**—Bulletin 632, 10 pp. Describes newly designed models of a complete line of graphic meters, made in switchboard, wall, portable and other types. The Esterline-Angus Co., Indianapolis, Ind.

**Transformers.** Bulletin 172, 54 pp., looseleaf. Describes all types of Wagner distribution transformers. Construction features are profusely illustrated and described in detail. Wagner Electric Corp., 6400 Plymouth Ave., St. Louis, Mo.

**Induction Motors.**—Bulletin 111, 8 pp. Describes type AA Reliance squirrel-cage induction motors for two- and three-phase alternating current circuits, 40°C. continuous duty, open rating. Reliance Electric & Engineering Co., Ivanhoe Rd., Cleveland, Ohio.

**Potentiometers.**—Bulletin, 8 pp. Describes potentiometers for research, standardizing and educational laboratories. Kelvin and Wheatstone bridges and resistance boxes are part of the line. Gray Instrument Co., 64–70 W. Johnson St., Germantown, Philadelphia, Pa.

**Dry Metallic Rectifiers.**—Bulletin. Describes a new unit of the type "F" rectifiers, providing a reliable source of small amounts of d-c. power for the operation of sensitive electrical equipment such as relays, electromagnetic counters, industrial control devices, etc. B-L Electric Mfg. Co., 19th & Washington Ave., St. Louis, Mo.

**Dust Filters.**—Bulletin, 28 pp. Describes the application of air filters now installed in many industries. A chapter is included illustrating the use of such filters in connection with the air cooling of various types of electrical equipment such as turbogenerators, synchronizing condensers, frequency changers, substations, etc. American Air Filter Co., Inc., Louisville, Ky.

**Cedar Pole Specifications.**—Bulletin (Supplement No. 2), 24 pp. Contains the new American Standards Association specifications for both Northern White and Western Red cedar poles with other relevant information and data. Preparation of poles for butt treatment through the use of new perforating machines is described. The MacGillis & Gibbs Company, Milwaukee, Wis.

**Nofuze "De-ion" Circuit Breakers.**—Catalog 2246, 76 pp. Describes Nofuze load centers, panelboards, switchboards, meter services, outdoor and indoor commercial and industrial type circuit breakers, all using the "De-ion" principle of arc extinction, which enables the elimination of fuses and knife switches for circuit protection and control. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

**Fuse Links.**—Bulletin 511, 8 pp. Describes the following types of Matthews fuse links, -bimetallic universal; fast blowing universal; open type bimetallic universal and spring type. Ampere ratings, catalog numbers, time current curves, fusing schedules indicating correct size link to use and proper method of application are discussed. W. N. Matthews Corp., 3700 Forest Park Blvd., St. Louis, Mo.

**Magnetic Clutches.**—Bulletin, 16 pp. Describes three types of Dings magnetic clutches—single disk, multiple disk, and serrated disk applications for special and general power transmission. A number of installation diagrams are reproduced and the method of calculating the required horsepower rating is discussed in detail. Extensive tables of performance data are also included. Dings Magnetic Separator Co., Milwaukee, Wis.

**Coupling Condensers.**—Bulletin 601-H, 24 pp. Describes a new development consisting of coupling condensers as a means of securing low voltage from high voltage circuits for operating instruments such as voltmeters, synchronoscopes and relays. Included is a detailed discussion of the electrical characteristics of circuits for various set-ups, with curves and wiring diagrams. Economies which are achieved are also presented. Ohio Brass Company, Mansfield, Ohio.

**Motors.**—Bulletin 210, 20 pp. Describes the Noel polyphase capacitor motor, which employs capacitors in a patented connection to obtain internally a power factor of unity (100%), or 80% leading, in squirrel cage and slip-ring induction motors. In addition to possessing all the advantages of the ordinary motor it is claimed that the Noel motor has a greater starting torque, a lower starting current, better efficiency, and higher speed at all loads. The Ideal Electric & Mfg. Co., Mansfield, Ohio.

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## This Month—

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Spillway as seen through the main doorway of the British Columbia Power Corporation's new Ruskin hydroelectric plant near Vancouver, B. C. Those attending the forthcoming Pacific Coast convention will have opportunity to visit this and other interesting plants.

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THE PROXIMITY effect may be utilized to control the path of electric current used for heating where it is desired that the heating be confined to predetermined strips of the conducting bodies. *p. 559–562*

PRIVATE-WIRE teletypewriter service provides the speed, accuracy, and wide coverage necessary in the communication facilities of the modern police system. Several statewide networks now are in use. *p. 550–553*

A VOLTAGE LIMITING gap for protecting power station apparatus has been developed, the breakdown characteristics of which can be varied over a wide range so as to conform to the characteristics of the station insulation. *p. 579–582*

FIELD observations of conductor vibration on electric power transmission lines substantiate the results of laboratory investigations. Results show that adequate practical protection can be provided by armor rods or dampers. *p. 562–568*

A 3,000-KW sectionalized mercury arc rectifier has been found by tests to have an efficiency one per cent higher than that of the conventional single unit type. *p. 576–579*

MAN'S RETREAT from light into darkness and from ventilated atmosphere to stagnant air is exacting its penalty. So says a medical authority in the twelfth article in the Engineering Foundation's Symposium, "Has Man Benefited by Engineering Progress?" *p. 553–555*

ULTRA precise practical timekeepers of today are of one of 2 classes, depending upon whether the restoring force is gravity as in pendulum clocks, or elasticity as in quartz crystal oscillators. The latter type is a development of recent years and has progressed so that the constancy of rate is comparable with that of the best pendulum clock. *p. 542–549*

ECONOMIC factors are important these days, especially where they concern one's own pocketbook. Members planning to attend the A.I.E.E. Pacific Coast convention August 30 to September 2, 1932, in Vancouver, B. C., may be attracted by the reduced entertainment fees and the exchange rate between Canadian and U.S. currency that at present favors U.S. currency if the exchange be made at a bank. *p. 588.* Abstracts of technical papers scheduled for presentation are published in this issue. *p. 583–586*

COLORFUL pictures of Baltimore, Md., and its attractions for those attending the A.I.E.E. Middle Eastern District meeting, to be held in that city October 10–13, 1932, are presented in a preview written by a member of the local convention committee. *p. 587*

IMPORTANT discussions of papers presented during the Institute's recent summer convention at Cleveland, Ohio, June 20–24, 1932, have been summarized. *p. 590–595*

EDUCATION has been the subject of a number of recent papers presented before the Institute. One of these papers analyzes the various electrical and related subjects in the program for electrical engineering in a number of technical institutions. *p. 568–571*

INTEREST in the "Letters to the Editor" columns of ELECTRICAL ENGINEERING is growing rapidly. These contributions take many forms. Responses which have been received indicate that these letters are widely read. *p. 597–599*

A TENTATIVE standard for engineering abbreviations has been adopted by the sectional committee on scientific and engineering symbols and abbreviations of the American Standards Association. This tentative standard is strictly an editorial specification. The terms most commonly used in electrical engineering literature are presented in this issue. *p. 589–590*

# To Members of the Institute—

IN ASSUMING the duties as your president, I welcome the opportunity afforded through Electrical Engineering to express my deep appreciation of the honor you have conferred upon me and to say a few words concerning the activities of the Institute for the coming year.

We are passing through a most difficult period and if we were to approach the year ahead with the least hesitancy or lack of confidence, we most certainly would not make the progress which has been so characteristic of the Institute in past years. However, we do not lack confidence as to the future; we recognize that we have but paused in a forward movement toward even greater technical and professional achievements. If we recognize this period, therefore, as a golden opportunity to consolidate our forces and build an even better organization for the future opportunities so definitely ahead of us, I am sure that we will not only carry on with still greater benefit to each other and to society as a whole, but also we will establish an even higher esteem in the mind of the public as to the importance and value of our profession.

We have but to look back a relatively few years to realize the remarkable advances that have been made in a short span of time in all phases of the arts and sciences with which we are concerned. Not a day passes without new vistas opening before us and revealing the way to new opportunities which cannot but lead to further material improvements and social advancements. Occasionally we hear the question raised as to whether scientific research and the general extension of engineering knowledge are not proceeding too rapidly for the common good, and consequently by some process might better perhaps be retarded. Aside from the impracticability of such considerations—touching as they do on man's curiosity about the unknown, or the stopping of the flow of new things which man believes to be valuable additions to social life—those who have given these matters serious study realize that the problem centers not in the products of science, but rather in the fact that our knowledge as to the proper use of the results of our scientific advancements has not developed nearly as rapidly as have the products of our research and engineering activities. These are matters which we of the Institute who are concerned in one way or another with the fundamental or applied sciences must consider. Our opportunity lies before us in the chance to help to bring about the effective general understanding of these matters that seems so necessary.

Not only in those things of which I have spoken, but likewise in the general solution of the problems which confront the world at large at the present time, there is urgent need for the help of individuals trained to discover facts and able to turn our efforts in the directions which such facts indicate. By basic training and practical experience, the engineer is indeed qualified to assist in just such a challenging task, and I am confident that we shall find him taking an ever greater and greater part, in full cooperation with others, in finding the solution of the serious problems confronting our nation and the world in general.

It seems to me, therefore, that we are in an era when the problems of the engineering profession are undergoing some rather important changes in their fundamental aspects, but in spite of our present temporary difficulties, I believe that these very changes, as well as other factors, all point to further progress and opportunity for those of our profession.

Within the Institute itself, this next year naturally will present many difficult problems and we should be prepared to shape its policies and procedures to conform to the times and conditions as encountered. Financial matters will require most careful consideration to the end that, while maintaining the financial integrity of the organization, we may as far as practicable continue the essential services to our members. I bespeak your hearty support of the headquarters and committee personnel faced with this and other important problems incident to these trying times, including the difficult questions involved in the Institute's publication services.

To our committees and the activities of our Sections we look, as in the past, for the spreading of interest and the enhancement of the value of our society to our members. At no time in Institute history have the activities of these groups been more important than at present, when it is hoped that we may not only hold together our great organization to as nearly as possible its full membership, but also add to its strength and solidarity.

Always of the greatest value, but now of more than usual importance, I believe, are the activities of our Student Branches. The problems confronting our younger members are more than usually difficult at this time, and it is hoped that the cooperation between our Sections and Branches may be fostered to an even greater and more effective degree than in the past. Such contacts must inevitably result in mutual encouragement, and benefit not only our student members but also our older members.

As for myself, my service in the Institute long has been one of my greatest pleasures, and I welcome with keen anticipation the new opportunities which will be afforded me as your president to break down the barriers that distance creates for us, visiting again the various Sections, and through professional as well as personal contact have the privilege of carrying on with you the important activities which we shall find in hand during the coming year.

**PRESIDENT**

# Modern Developments in Precision Timekeepers

Clocks of the gravity or pendulum type have for many years been used as precision timekeepers; but through recent refinements they have been made more accurate and reliable. Another development of the last decade is the use of the elasticity of quartz crystal oscillators as the restoring force in precision timekeepers; this has been made possible by the vacuum tube and associated electrical circuits. Both types of timekeepers are discussed in this article.

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AT THE BEGINNING of the present century it was believed by many that the limit of accuracy attainable by mechanical clocks had been reached. This presumption was based on the performance of specific mechanisms which had indeed been brought to a high state of perfection, but this presumption did not allow for the possibility of other types of mechanism for measuring time or for certain refinements which since then have more than doubled the accuracy and reliability of the best clocks then available.

As the words clock, chronometer, etc., have come to have definite technical meanings in the art, the more general term "timekeeper," will be used. In the broadest sense a timekeeper may be defined as any physical means that can be used for the subdivision of time into intervals known in terms of a standard time interval. Thus, any periodic phenomenon can be adopted in a timekeeper provided its period can be recorded in terms of another. In this sense the earth and the moon are timekeepers, as are vibrating pendulums, tuning forks, and other sustained oscillators.

As all man-made timekeepers are essentially "oscillators" consideration will first be given the equation of motion of a simple oscillator which can be expressed as $M\ddot{x} + R\dot{x} + Sx = A \sin(\omega t + \phi)$ where $M$ corresponds to the mass, $R$ to the resistance or damping and $S$ to restoring force proportional to displacement $x$. The right hand term represents the sustaining force required on account of the dissipation of energy in the oscillator. For an oscillator to be a perfect timekeeper, all of the quantities, $M$, $R$, $S$, $A$, and $\phi$, must remain invariable. While $M$ and $S$ are the chief rate governing quantities, the others from a design point of view are the most difficult to control.

The ultra precise practical timekeepers of today may all be contained within 2 classes, depending upon where $S$ (the restoring force) is

1. Gravity (as in pendulum clocks)
2. Elasticity (as in quartz crystal oscillators)

The second class is a development of the last decade and was made possible by the development of the vacuum tube and associated electrical circuits. Intercomparisons between timekeepers of the 2 classes provide a most valuable means for the study of changes in gravity and related phenomena. These 2 classes are discussed separately.

## GRAVITY TIMEKEEPERS

Unfortunately the motion of a pendulum is not quite simple harmonic motion since the restoring force varies as the sine of the angular displacement (instead of directly as the displacement) and therefore the period is not truly independent of the amplitude. This can be seen from the equation of motion of the pendulum which in its simplest form, neglecting damping and sustaining forces, is

$$Ml\ddot{\theta} + Mg \sin \theta = 0$$

The free period $T$ for any given angular displacement can be expressed by the series:

$$T = 2\pi\sqrt{\frac{l}{g}}\,(1 + 0.0625\,\alpha^2 + 0.00358\,\alpha^4 + \ldots)$$

where $\alpha$ is the maximum deflection from midswing expressed in radians. The corresponding change in rate expressed in seconds per day is shown in the curve, Fig. 1. Various attempts have been made to construct pendulums having a period independent of arc, but mechanisms to accomplish this result always have introduced larger irregularities than those which they attempted to cure. Practical design has been confined to keeping the amplitude small and to providing a governing action so that any slight increase in amplitude causes an opposing tendency to decrease the amplitude, or *vice versa*.

The old anchor recoil escapement accomplished this by increasing the friction on the pendulum with

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Essentially full text of "Modern Developments in Precision Clocks" (No. 32-52) presented at the A.I.E.E. winter convention, New York, N. Y., January 25-29, 1932.

increase of amplitude. The inertia escapement in the Shortt clock attains a similar result without the serious disadvantage of introducing friction. This inertia escapement is based on the principle that a weight rolling down an inclined plane applies a greater horizontal force to a slowly moving plane than to a faster moving one. A suitable inclined plane attached to a pendulum receives an amount of energy roughly inversely proportional to the amplitude, or to the velocity at midswing. As the amplitude increases, the energy delivered into the system becomes less. But in spite of these controls the amplitude does vary in fact, which at the present time probably accounts for more irregularities than any other factor. Dr. J. Jackson has shown that if the daily amplitude is regularly recorded and the clock rate corrected accordingly, a number of the irregularities in the Shortt clocks at Greenwich can be explained.

If a direct amplitude control could be applied to a clock, such corrections should not be necessary. Such a method is now being tried on a Shortt clock in the Loomis Laboratory. When the amplitude of the pendulum exceeds a predetermined amount by even 0.0001 in., a signal is sent, via a pointed electrode which hangs in the evacuated pendulum casing, to a vacuum tube which operates a relay, so that the next 30-sec. driving impulse is omitted. The electrode is so adjusted that about every fifth impulse is omitted in this way. With this control the constancy of rate appears to be improved, but at least a year's record is needed for conclusive proof, as the variations which this device seeks to control usually only occur at intervals of several months.

The complete solution for the period of a pendulum swinging in a resisting medium, such as air, involves a factor $\sqrt{1 + kR^2}$ where $R$ is the resistance to motion and $k$ is a constant depending on the structure of the pendulum and the nature of the drive. Although it would appear from this that all pendulums should be operated in a high vacuum, practically it has been found that, from the standpoint of stability of period with pressure variation, the most satisfactory pressure for the Shortt clock is about 15 to 20 mm. of mercury. When the pressure is very low or at zero, the arc when not definitely controlled is very unstable and causes large changes in rate; but in the neighborhood of 15 mm. of pressure there is a stabilizing action due to the air friction, and a neutralization of the following four effects of pressure variation:

1. Change in the restoring force due to buoyancy of the pendulum in air.
2. Change of center of gravity due to buoyancy when the pendulum is made of dissimilar materials.
3. Change of effective mass due to air carried along by the pendulum.
4. Change of friction and consequent change in arc.

The first and fourth are probably of greatest importance. With decrease in pressure the first decreases the period and the fourth increases it. At the critical pressure the 2 effects are about equal and opposite. In the determination of gravity, where very precise pendulums are used, all of these factors must be considered carefully.

When the amplitude control device previously described is used, the pressure can be reduced to a small fraction of a millimeter, which thereby reduces the effect of friction to a minimum. The term $\sqrt{1 + kR^2}$ then becomes practically unity and the required sustaining energy can be very much reduced.

## VARIATIONS IN INERTIA

Because of its effect on inertia, the expansion of the pendulum with temperature must either be reduced or compensated for. At the present time practically all clocks of high precision employ invar pendulum rods with bobs of type metal or invar. The bob rests on an expansion collar, the dimensions of which are calculated to compensate for the lengthening of the rod. Some recent studies in Japan have produced a "super-invar," to use the expression given, which may have a zero or even a slightly negative coefficient of expansion. If these new alloys are as stable as invar, they may have an important use in precision clock making, as the entire pendulum could be made from a single piece of material.

With the new technique recently developed in the laboratories of the General Electric Company it is now possible to produce pieces of clear fused quartz large enough to construct the entire pendulum for a clock. Some experiments are now being conducted with such clocks in the Loomis Laboratory. Fused quartz has a temperature coefficient of expansion of about 0.5 part in $10^6$ per deg. cent. A temperature variation of one degree would therefore cause a change in rate of only 0.02 sec. per day due to this effect alone. In a constant temperature vault with a fused quartz pendulum a variation of 0.01 deg. would affect the rate only 0.0002 sec. per day; means have been developed whereby temperature can be controlled to within 0.01 deg. over long periods.

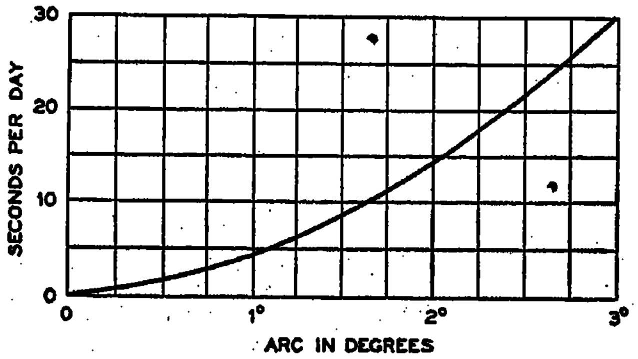


**Fig. 1. Change of rate of pendulum with semi-arc, expressed in seconds lost per day**

There are 2 other major effects which should be considered in connection with pendulum length. These are (1) variations in the position of the point of oscillation, and (2) the instability of materials with time, in other words, aging. The effect of knife edge wear on the period of an ordinary pendulum is appreciable. A wearing of 0.001 mm. will change the rate of a seconds pendulum nearly 0.1 sec. per day. Largely for this reason, a flexible spring suspension of elinvar[4] is used in most precision clocks. But even the spring is suspected of changes in length, and, what is just as bad, also of variation in stiffness which would change the point of flexure and the restoring force. Aging effects in the pendulum rod can be reduced only by finding better materials. It may be that fused quartz or possibly some large single crystal will be found finally to be the most suitable material to use.

The effect of knife edge wear on the period of a pendulum in theory can be avoided almost entirely by suspending the pendulum at a distance from its center of mass equal to the radius of gyration about that point. This simple principle of mechanics has of course long been recognized and experiments are being conducted in Germany[6] and elsewhere to determine its value in a precision timekeeper. In the case of a uniform straight rod this distance should be $\frac{1}{2\sqrt{3}}$ of the total length from the center. With this condition fulfilled a change in this length due to knife edge wear of one part in a thousand would affect the period less than one part in a million.

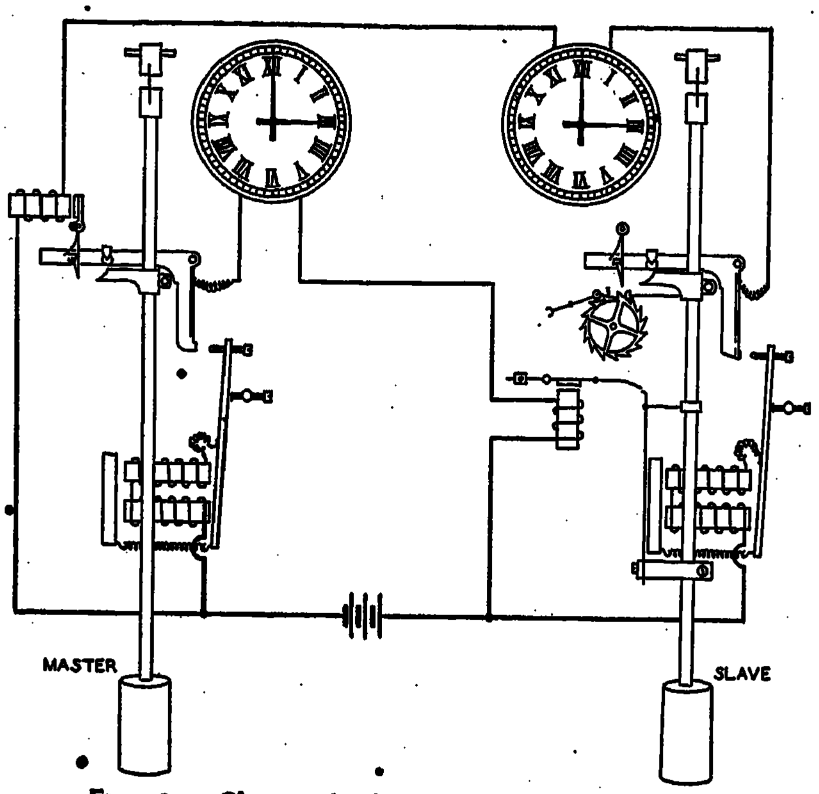


Fig. 2. Shortt clock mechanism and circuit

THE DRIVING FORCE

The terms on the left-hand side of the fundamental equation at the beginning of the article have been considered briefly. The right-hand term—the driving force—and especially the quantity $\phi$, the phase angle, which presents perhaps the most difficult problem in the design of all timekeepers, will now be considered.

The impulse should be delivered to the pendulum at the time when the velocity is at maximum; that is, at the center of the swing, in order to reduce to a minimum the effect of variations in the driving force upon the rate. If the impulse is applied before the instant of maximum velocity, the rate is increased momentarily. If the impulse is applied after the instant of maximum velocity the reverse is true. Of course the impulse actually is of finite duration and the desired effect is approximated by supplying the pulse symmetrically with respect to the instant of maximum velocity, thereby tending to neutralize the acceleration and retardation effects. The necessity for this method of applying sustaining power pulses to a pendulum has been realized almost from the beginning of precision clock history but cannot be overemphasized.

The 3 clocks most often recognized as precision timekeepers are the Leroy, Riefler, and Shortt. One or more of these is to be found in most of the important time laboratories and astronomical observatories throughout the world. In the Shortt clock the impulse to the master pendulum is controlled by means of an auxiliary or "slave" pendulum which in turn is automatically synchronized with the master pendulum to within ±0.003 sec. at all times. The means by which this is accomplished can be seen from Fig. 2 which shows the master and slave pendulums with all the essential control elements, and the counting or time indicating dials. Although the master pendulum determines the rate of the system, the slave pendulum and associated mechanism does the work of releasing the driving pulses at the proper time. The slave pendulum, through a jeweled ratchet and pawl-operated count wheel, releases mechanically a weight arm once each 30 sec. at just the right time so that a small wheel on the gravity lever, rolling down a curved inclined track associated with the slave pendulum rod, imparts the sustaining impulse to it. As soon as the mechanical impulse is delivered, this arm closes an electrical contact which resets the weight arm before the return swing of the pendulum, in readiness for the next 30-sec. impulse. The current which resets the slave clock drive also releases the impulse mechanism for the master clock thereby avoiding the use of any mechanical connection with the master pendulum other than that of the impulse wheel. As in the case of the slave drive mechanism, the impulse lever makes an electrical contact after delivering its impulse to the master pendulum, which resets the gravity arm and in addition operates the "hit and miss" synchronizer on the slave clock. The slave pendulum normally runs a little slower than the master and is speeded up when necessary by means of a spring attached to the pendulum rod which is engaged by the synchronizer whenever the slave lags

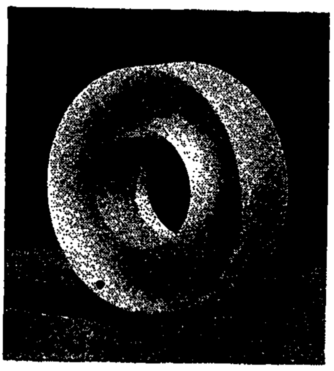


Fig. 3. (Above) Quartz crystal with zero temperature coefficient used in crystal clock

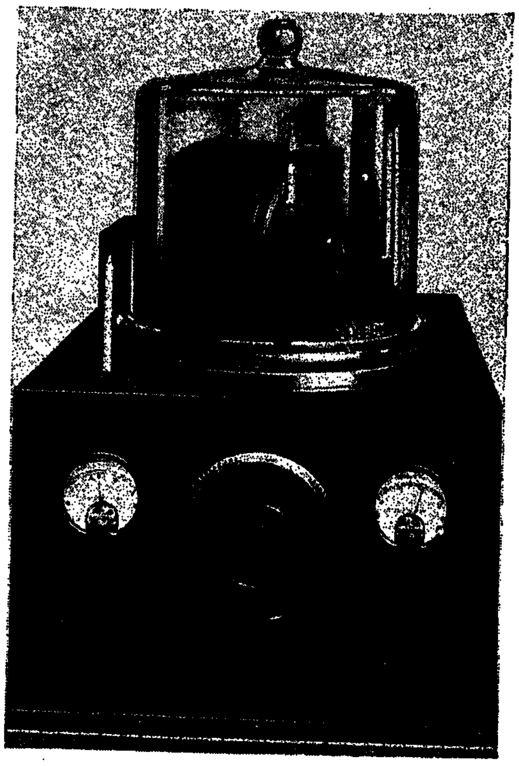


Fig. 4. (Right) Complete 100,000-cycle quartz oscillator

by more than 0.002 sec. behind a definite phase relation to the master.

There are reasons to believe, however, that small changes in phase do occur, especially with variations in amplitude. Probably future improvements in gravity timekeepers will include improved methods for keeping the phase of the driving force more nearly constant.

## CRYSTAL OSCILLATORS AS TIMEKEEPERS

Within recent years developments in methods of keeping time have progressed so far that the constancy of rate of certain mechanical resonators, maintained in vibration by vacuum tubes, may be comparable with that of the best pendulum clocks. Such oscillators have the chief attributes of a good clock and can be used to operate or control a wide variety of time mechanisms with even greater versatility than the conventional pendulum.

The most accurate oscillators of this type known to the authors are controlled by plates of quartz crystal vibrating at a high frequency; that is, high in comparison with the frequency of a pendulum. Probably the most accurate of these at the present time is a set of four 100,000-cycle oscillators that has been built by the Bell Telephone Laboratories principally for use as a primary frequency standard. These laboratories also have supplied a similar set of oscillators for the same purpose to the U.S. Bureau of Standards.

In this type of oscillator the frequency is controlled by a ring of quartz crystal as shown in Fig. 3, about 3 in. in outside diameter. The frequency of the oscillator is the same as that of the crystal; that is, 100,000 cycles per second. One complete oscillator including temperature and pressure controlled crystal and shielded vacuum tube circuit is shown in Fig. 4.

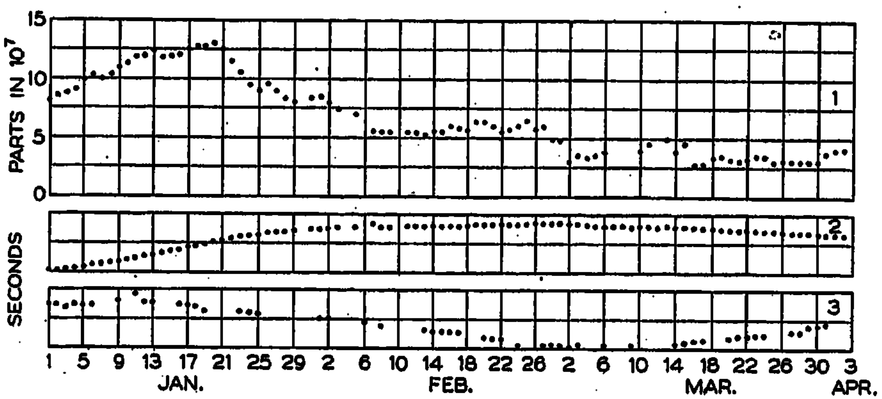


**Fig. 5. Performance data for crystal clocks**

Curve 1. Rate comparison between crystals 1 and 2
Curve 2. Integral of curve 1, showing running comparison
Curve 3. Indicated time of one crystal clock vs. corrected signals from U.S. Naval Observatory

In order to operate clock mechanisms in the most direct way it is necessary to control from this high frequency another which is low enough to operate a synchronous motor. This is done by an electrical circuit known as a sub-multiple generator which controls one frequency at a definite fraction of another in absolute synchronism. Several types of circuit have been used for this, all of which are as positive in action as a set of gears. Usually the low frequency used to operate the motor is 1,000 cycles. Each pole on the motor in motion therefore corresponds to one millisecond in time; hence, any variation in the motor mechanism or operation can amount at most to a fraction of a millisecond. Such a motor can be used to operate time indicating or measuring apparatus in a wide variety of forms.

As a rate controlling element a crystal of quartz used in this way has a number of outstanding useful properties. As previously discussed, the rate of vibration is controlled chiefly by the effective mass and stiffness of the resonator. On account of the chemical stability of the substance $SiO_2$ and the physical stability of the crystal structure of quartz these may be expected to be constant to a high degree. At the present time, variations introduced by the vacuum tube circuit and the crystal mounting are such that no conclusive evidence of aging in the quartz has been obtained.

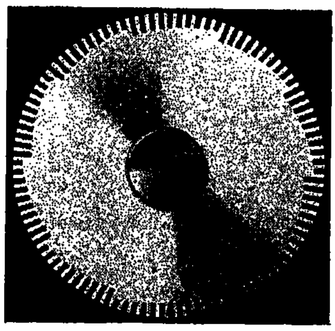
Since the elasticity is a constant for such displacements as are required (amounting to less than one part in 100,000 change of dimensions) the rate is substantially independent of amplitude. The amplitude can be controlled at nearly a constant value, however, by proper adjustment of the vacuum tube circuit.

The temperature coefficient of frequency can be made as near to zero as required at any given operating temperature by properly adjusting the shape of the resonator. Crystals which have been in continuous operation for 3 years have not shown any appreciable change in this adjustment.

Crystals are not affected by gravity or magnetic fields and can be shielded readily from electrostatic fields. They can be mounted so as to be relatively immune to vibrations which always seem to be present in the earth, especially near traveled roads and manufacturing centers. This may be found to be an important factor in the location of accurate clocks in cities or near earthquake zones. The crystals referred to above are mounted on the seventh floor near a much traveled thoroughfare in New York City.

The electromechanical coupling to a crystal for imparting the sustaining energy to it makes use of its piezo activity. As far as has been determined there is no increase in decrement directly due to this means of coupling, although of course through this coupling properties of the electrical circuit such as damping may be manifested in the crystal. The logarithmic decrement of a 100,000-cycle low-coefficient crystal mounted in air at atmospheric pressure and coupled into the electrical driving circuit is about 0.00012.

**Fig. 6. Special light interrupter for the production of accurate timing signals by means of a photoelectric cell**



Probably the largest rate disturbing factors in the crystal clock at the present time are due to effects of the phase $\phi$ of the applied driving force. This factor varies slightly with circuit variables, aging of vacuum tubes, and power voltage variations. Developments now in progress indicate, however, that the effects of these variables can be greatly reduced, and a marked improvement in performance should result. The performance, as clocks, of a pair of crystals is shown for a 3-month period in Fig. 5.

While the crystal clock assembly is more costly than a pendulum clock and requires more elaborate associated electrical equipment, it is believed for many purposes to be decidedly superior because of its great versatility. For example, its rate can be adjusted at will over a sufficient range to allow for such aging effects as occur. Also, the phase, or indicated time, can be adjusted with extreme accuracy. This can be done most advantageously in the electrical circuit by means of a phase shifter which operates continuously through 360 electrical deg., or any fraction or multiple thereof. If used in the 100,000-cycle circuit, one complete turn of the dial corresponds to a final adjustment of 0.00001 sec., which obviously is greater accuracy than needed in any ordinary time mechanism.

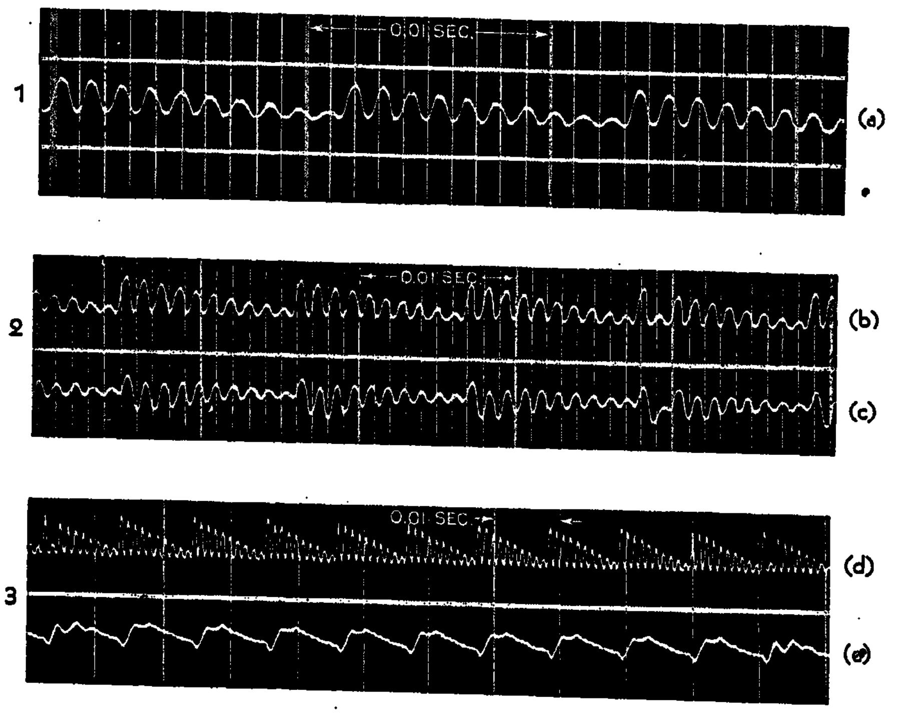


**Fig. 7. Oscillograms of time signals produced by photo-electric cell method**

Oscillogram 1. Direct signal (a) obtained from photoelectric cell
Oscillogram 2. Direct signal (b); and (c) the same signal transmitted by radio. A method is indicated for marking every 0.1 sec.
Oscillogram 3. Direct signal (d); and (e) same signal rectified for recording with only 0.01-sec. resolution

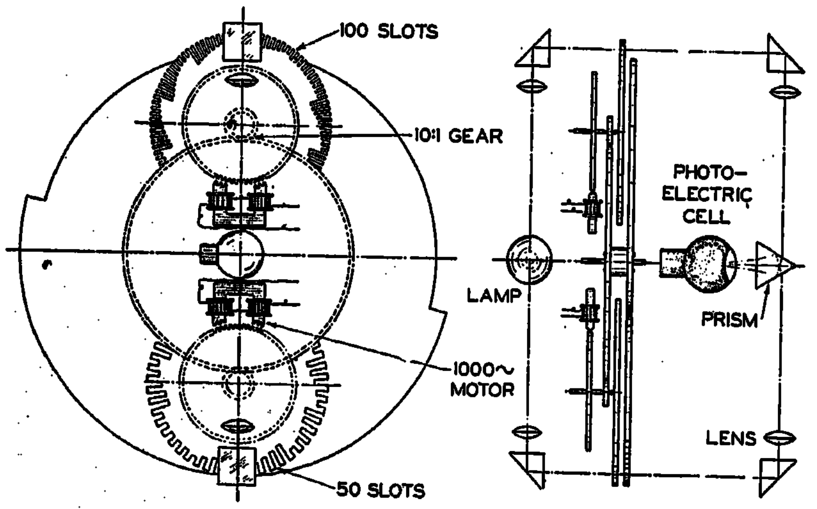


**Fig. 8. Proposed method for production of accurate time signals by photoelectric cells**

The accuracy of inter-comparison of crystal clocks may be very high. An absolute comparison accurate to better than 0.00001 sec. can be maintained continuously, while under special conditions short time comparisons accurate to one part in $10^{10}$ can be made. This high accuracy of comparison is due chiefly to the large number of vibrations per second, 200,000 times greater than with a "seconds" pendulum. Even greater accuracy of comparison could be obtained by the use of higher frequency crystals, but for reasons of convenience and greater freedom from the effect of external circuits and the mounting, the lower frequency is preferred.

One application of considerable interest is that 2 clock mechanisms can be operated from the same crystal control in this way so that one keeps true mean solar time when the other keeps true sidereal time.[9] It can be shown readily that any ratio of rates can be obtained for such a purpose accurate to at least one part in $10^{10}$ without the use of an unduly complicated mechanism. Lord Grimthorp has shown why a pendulum cannot be used for this purpose, but his reasons do not apply to the crystal control method.

By means of a photoelectric cell and a shutter of the type shown in Fig. 6, signals of extreme accuracy can be controlled which could be used for radio transmission of time signals or for any purpose requiring great accuracy. When this disk is rotated at 10 revolutions per second by a crystal controlled motor the current from the photoelectric cell is 1,000 cycles modulated in the manner indicated in oscillogram 1 of Fig. 7, at 100 cycles per second. By marking one 0.01-sec. element, as for example by partially blocking one sector, a positive 0.1-sec. indication is obtained. The oscillograms shown in Fig. 7 were made with the disk shown, and indicate how with the use of a suitable oscillograph, a continuous time signal can be recorded that can be read to a fraction of a millisecond. This resolution would be very useful for accurate time measurement work, for studies in radio propagation times, and for measurements of gravity. Observers requiring less resolution than this could obtain 0.01-sec. accuracy by the use of a rectifier and a recorder accurate to only 0.01 sec. The same is true for 0.1 and 1.0-sec. accuracy by a suitable choice of transmitting disk and receiving equipment.

The second oscillogram shows the signal direct from the disk and after it had gone through a complete radio transmitter and receiver consisting of a total of 11 tandem vacuum tube stages and associated equipment. As indicated, the total delay encountered was about 0.1 millisec., and the distortion is not appreciable. Of course any combination of make and break signals can be controlled in this way using either a continuous or a modulated tone. If desired a series of $^1/_2$-sec. dashes could be controlled, interspaced by a dot-dash code to designate each dash.

A complete time signal control mechanism based upon this idea is shown diagrammatically in Fig. 8. In the method shown, light from a straight filament lamp is imaged on the slotted edge of a disk driven at 10 revolutions per second by a 1,000-cycle motor. The light entering the photoelectric cell is modulated as indicated, at 1,000 times and 500 times per second alternately, and controls a corresponding electrical signal. The slow speed shutter, rotating at one revolution per second, causes the effective light path to alternate between the 2 disks once each second, and gives a corresponding variation of electrical signal. This signal can be used for any resolution from one second down to one millisecond and can be received through static and fading. It can be reduced to the dash-space type by the use of a simple voice-frequency filter to suppress the undesired half signal, or used as a continuous signal for oscillograph recording.

Among the advantages of the crystal clock should be mentioned that in order to control any number of clock mechanisms with the same precision it is necessary only to distribute the constant frequency current derived from the crystal to the separate mechanisms. This can be done on any scale economically feasible.

## EXPERIMENTS IN TIME AT LOOMIS LABORATORY

The clock installation at the Loomis Laboratory, Tuxedo Park, in brief consists of 3 Shortt clocks mounted in an especially favorable location practically free from traffic and electrical disturbances, and carefully temperature controlled. The excellence of the location is enhanced by the fact that the clock vault is excavated in the solid rock of the mountain on which the laboratory stands, and the 3 massive masonry piers for mounting the clocks are effectively a part of this rock. One of the 3 Shortt master pendulums in its casing is shown in Fig. 9 mounted on its pier within the temperature controlled vault.

By means of the Loomis chronograph[8] it has been possible for the first time to obtain a running phase comparison of a number of clocks with great precision. Prof. E. W. Brown and Dr. Dirk Brouwer have shown[10] that the probable error of the mean hourly rates as measured by this chronograph is less than 0.0001 sec. With a resolution of this order, it is possible to study some effects that would be forever unsuspected with the use of any comparison equipment used heretofore.

The rate curves on Fig. 10 will illustrate a case in point. These 3 curves show the differences in rates between the 3 Shortt clocks taken in cyclic order, plotted on a very open scale over a period of about 3 months. Although the mean rates over this and much longer periods are constant to one part in ten million, there are fluctuations in rate having for the most part perfectly definite periods. These fluctuations are real and a study[10] of the data by Professor Brown showed that the periods correspond to the differences in periods of the pendulums taken in pairs. This implies that there is coupling between the pendulums and that the rate of one is modulated by that of the others even though the pendulums swing practically in vacuum and are mounted on separate massive piers, and that they swing in planes 120 deg. apart. This would seem to show that massive as the piers have been made, they are not infinite in comparison with the 14-lb. pendulums, and that strains set up by each pendulum are felt in some degree by the others through the piers and solid bed rock.

A study was made of the performance of several actual installations of precision clocks, including Riefler clocks nos. 60, 70, and 151 at the U. S. Naval Observatory, Washington, D. C.; Riefler clock no. 412 and Shortt clock no. 29 at the Dominion Observatory, Ottawa, Can.; Shortt clock no. 11 at the Royal Observatory, Greenwich, Eng.; Leroy clock no. 1,185 at the Paris Observatory, Paris, France; and Shortt clock no. O at the Royal Observatory, Edinburgh, Scotland. This study showed that although the rate variations of the 3 Shortt clocks at the Loomis Laboratory are quite appreciable as measured by the Loomis chronograph, the relative performance, as clocks, is all that could be desired, and indicates that factors having small but real effects upon the rate can be detected by a chronograph with this high resolving power when they would not be observed at all by ordinary methods. The 3 rate curves and the 3 time curves of Fig. 10 are plotted to the same scale as the corresponding crystal data in Fig. 5.

**Fig. 9. (Right) Master pendulum in casing for one of 3 Shortt clocks located in the Loomis Laboratory**

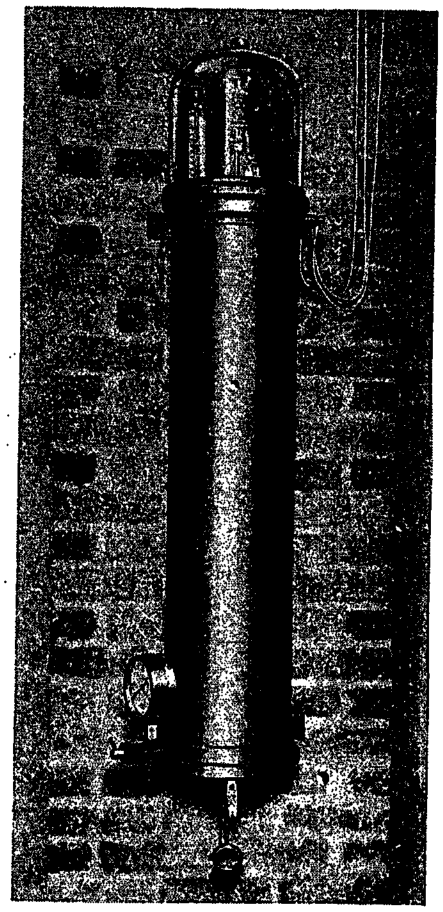
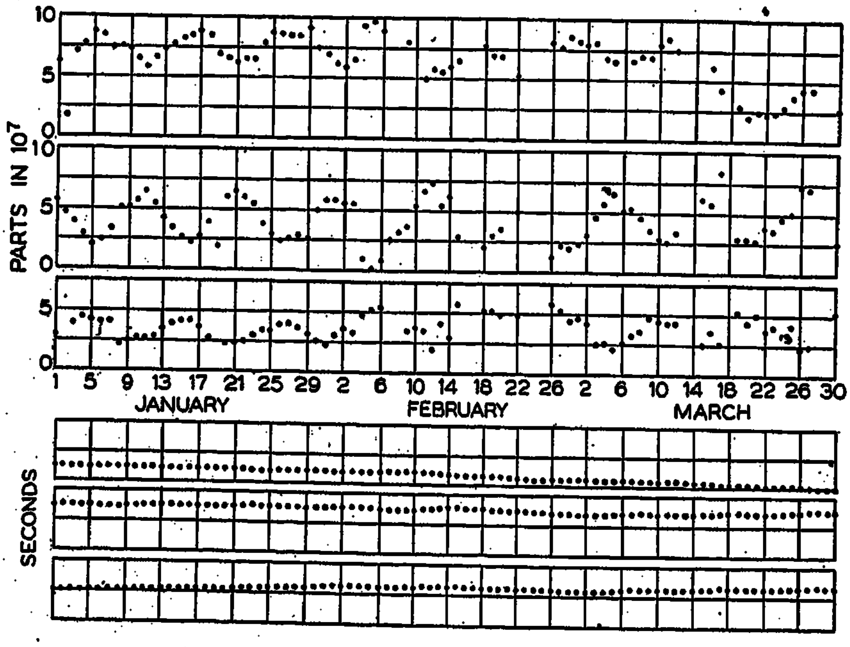


**Fig. 10. (Below) Intercomparison of 3 Shortt clocks which are located in the Loomis Laboratory**

Rates are given in the 3 upper curves. Integrated rates are given in the 3 lower curves



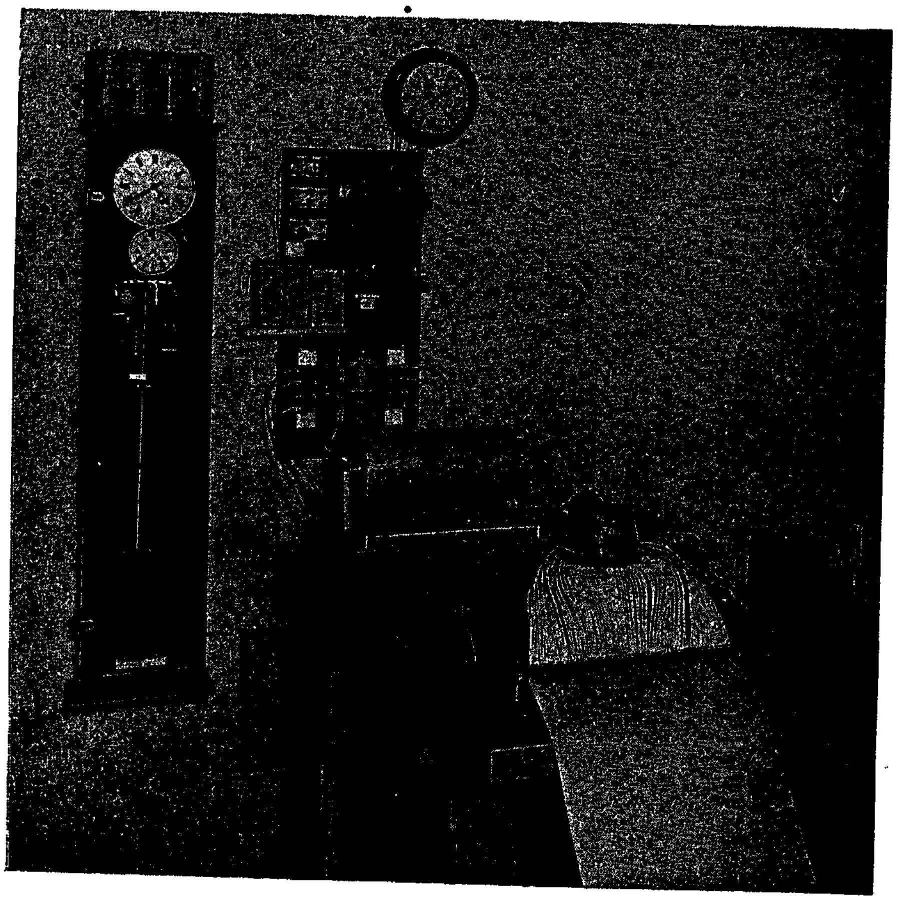


**Fig. 11. Loomis chronograph and one of 3 Shortt slave clocks in the Loomis Laboratory**

The Loomis chronograph shown in operation in Fig. 11 consists of the following essential parts:

1. A strip of paper about 10 in. wide moving at a uniform rate between a long grounded electrode and a comb consisting of 100 separate equally spaced pointed electrodes.
2. A distributor having 100 segments separately connected to the 100 elements of the comb, operated at exactly 10 revolutions per second by a synchronous motor from a source of 1,000-cycle current.
3. A source of high potential consisting of an induction coil through the primary of which a large condenser is discharged when a record is to be made. A small condenser on the induction coil secondary stores sufficient energy to produce an intense spark of very short duration.
4. A single relay in the common circuit of all the time devices to be recorded on the moving paper strip.

If the relay is operated every time the distributor makes some exact whole number of revolutions a series of perforations will be made in a line parallel with the edge of the paper. If in the time between sparks, the motor revolves a whole number of times plus or minus 100, successive perforations will be displaced an amount corresponding to one millisecond in time. One second in time is represented by 10 complete transits of the chart, so that, in effect, the chart is 100 in. wide and the effective recording element moves at the rate of 500 ft. per min. Thus from the slope of the line of perforations with respect to the edge of the paper the difference between the rate of the distributor and the rate of the sparks can be determined with high precision. Similarly any number of separate sets of sparks can be recorded simultaneously on the same chart, using the same actuating relay and distributor. The relative rates may be determined by measuring the difference of slopes of the rows of perforations.

This is the method used for intercomparing the 3 Shortt clocks and for comparing them with crystal oscillators in New York City. To accomplish this, 1,000-cycle current controlled by the Bell Laboratories' crystal is sent over a private wire to Tuxedo and there used to drive the distributor as outlined above. The resulting records are continuous comparisons of the 3 Shortt clocks and the crystal, accurate to better than one millisecond in time.

Since the crystal does not respond to variations in gravity while the pendulum does, the difference in rates contains a term having the period of the lunar day, corresponding to the direct gravitation effect of the moon on the pendulums. Several months' records of the Loomis chronograph have been analyzed[10] by Professor Brown and Doctor Brouwer and a lunar term observed having the proper period and magnitude. A graph of the lunar effect derived in this way is reproduced from their paper in Fig. 12. The periodic gain and loss in indicated time is about 0.0002 sec. per lunar day.

The results of time studies obtained at the Loomis Laboratory have been very encouraging and it is planned to continue the researches in clocks and time measurement methods.

## Possible Future Investigations

No doubt there is a practical limit to the accuracy attainable in a timekeeper but as long as random changes in rate are observed which cannot be explained by uncontrollable properties of matter (such as Brownian movement) that limit has not been reached, even with the types of mechanism at present in use.

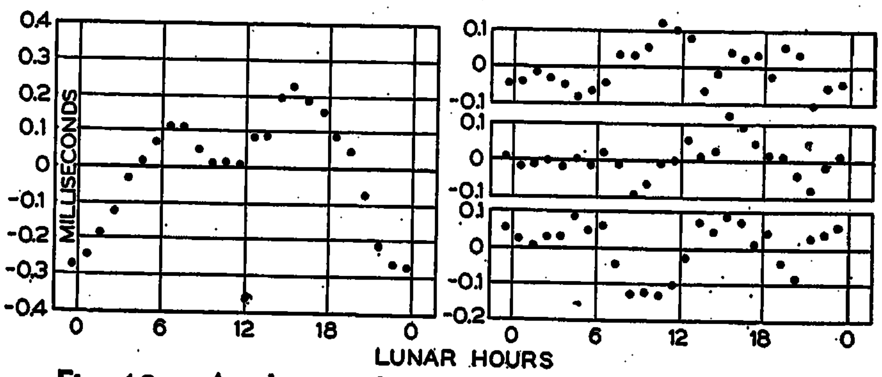


**Fig. 12. Analysis of comparison data between crystal clock and 3 pendulum clocks revealed the periodic lunar day variation shown in the left hand curve**

The suggestion has been made of utilizing the constant velocity of light between fixed points as a measure of period. At present the velocity of light is known to less than one part in a million. Even if it were known with greater accuracy, the practical difficulties of establishing such a standard, except in a very rough way, would be insuperable. In the first place the distance between the measuring points would have to be known to one part in a million, that is, better than 0.06 in. in a mile, assuming no other error, to define a standard good to only 0.1 sec. per day. Considering the difficulties in measurement, an accuracy of a little better than a part in a million is about all that could be expected of such a method by any means now known.

The extreme definition of some spectral lines indicates a very slightly damped oscillation of some sort in the atom, and some thought has been directed to means of making a frequency comparison between these vibrations and others of lower frequency that could be used to measure time as previously outlined. The effective logarithmic decrement of the "oscillator" behind the red line of cadmium can be estimated as about one tenth of that of a quartz resonator. The difficulties of utilizing this sort of thing as a time (or frequency) standard are: First, it is not known at present whether the "frequency" of an atomic disturbance has the same physical significance as vibrations-per-second and, second, even if the significance were the same, the orders of the 2 frequency ranges are so far separated that no means known at present could be used to effect the comparison. Besides, the energy of a spectrum line is no doubt made up of a large number of damped wave trains superposed in some fortuitous fashion as would cover the identity of separate cycles.

Probably the real final limit in the accuracy of timekeepers is concerned with the measure of our time standards. Some observations indicate that the rate of the earth's rotation is not constant, but that there are both systematic and apparently random changes in rate as compared with the motion of other astronomical bodies believed to be more stable. For example: About 1918 a rather abrupt change in rate was observed which amounts to about one part in thirty million. This is small to be sure, but points to the improbability that the rate of any phenomenon is absolutely constant. After all, time is relative and the most nearly accurate measure of time must always be in terms of the most nearly constant motion that can be observed.

At the present time in the official observatories of the various countries the usual procedure is to plot the star observations in terms of their master clock and then to draw a smooth curve, which curve is adopted as the official clock correction. To some extent the drawing of this curve is a matter of judgment, based partly on the number and certainty of the star observations and partly on the estimated performance of the master clock in terms of their other clocks. These observatories at the present time also transmit and record radio time signals and publish periodically corrections to these signals in terms of their "standard clock error." From these data alone it is not possible for any one observatory to compare its clocks directly with the clocks in another observatory. If the observatories would publish one additional number for each of their important clocks, namely, the comparison of each clock with their official time, it would be possible to compare the rates of the clocks in such observatory directly with clocks anywhere else in the world where the radio time signals can be received. This would involve only a very small amount of additional work as the numerical data have to be obtained in any case. It is well to note in this connection that the United States Naval Observatory has adopted a procedure which is very similar to this, the only difference being that instead of publishing the corrections to each of its principal clocks, it publishes a single number which represents the correction of the weighted mean of several clocks. This is an excellent beginning and it is hoped in the interest of future clock developments and of studies in gravity and related phenomena, that others will follow.

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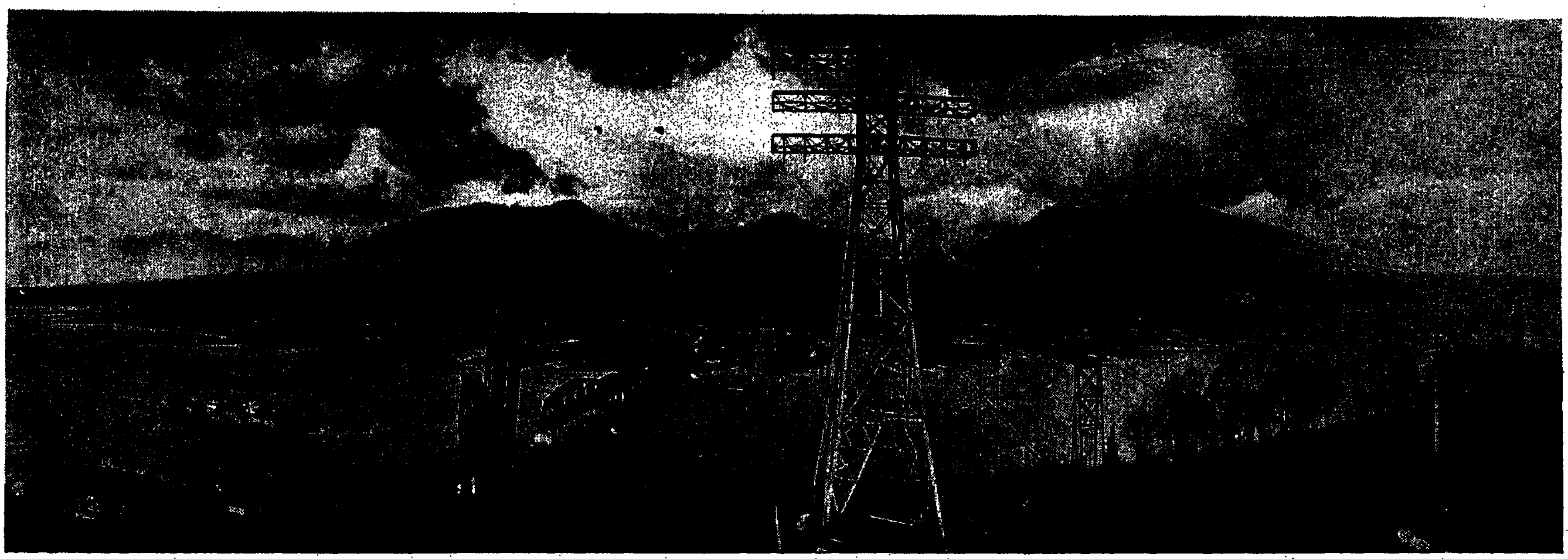

**Near the scene of the A.I.E.E. 1932 Pacific Coast convention, the Second Narrows, Vancouver, B. C.**

Here 2 34.6-kv. lines and 2 communication circuits of the British Columbia Electric Railway Company, Ltd., cross Burrard Inlet; the crossing is designed to carry ultimately 2 165-kv. lines, 4 34.6 kv. lines, and 4 communication circuits. Length of the main span is 1,641.5 ft.; minimum height above high water, 186 ft. Conductors on main towers and back-guys on anchor towers ride on sheaves

# Communication by Police Teletypewriters

Police organizations throughout the country rapidly are adopting the teletypewriter, the latest development in record communication. By this means alarms are typed at one point and simultaneously recorded in printed form at a large number of widely scattered stations. The engineering of facilities required for a modern police system involves the solution of many special problems.

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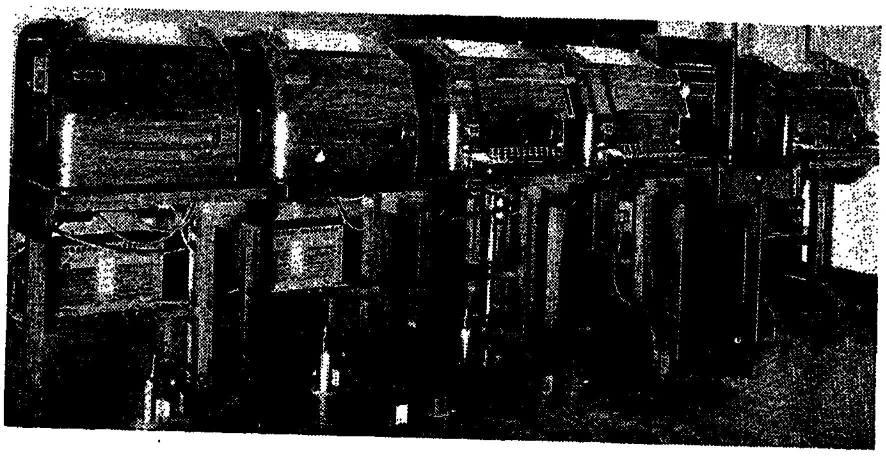

Fig. 1. Teletypewriter installation at the headquarters of Troop K, New York state police, at Hawthorne

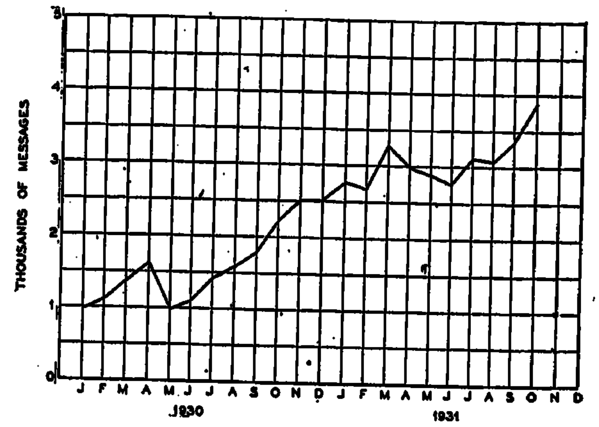

Fig. 2. Traffic on the teletypewriter system of the Pennsylvania state police, in number of messages per month

SPEED, accuracy, and wide coverage are important factors in the communication facilities of any modern police system. During the past 2 years there has been a definite and rapid adoption of private wire teletypewriter systems by the police as a means of communication between the different units within a police organization. The teletypewriter provides means for typing a message at one point and recording the message in typewritten form at a distant point as well as at the home station. These systems are now so widespread that approximately 40 per cent of the people of the United States live in areas protected by police teletypewriter systems.

The primary use of the teletypewriter by the police is to broadcast alarms, usually consisting of notices to apprehend suspects, watch for missing persons, or recover stolen goods. Teletypewriter systems also find a large field of usefulness in the handling of routine correspondence between units of the larger police organizations.

The different types of traffic handled on a typical police system are shown in Table I. These statistics were obtained from the Pennsylvania state police system covering the month of October 1931. The statewide broadcast includes messages from Harrisburg to each of the 110 municipal police stations throughout the state. It will be noted that more than 50 per cent of the statewide broadcasts had to do with stolen automobiles. Since these communications usually involve registration numbers and proper names, the printed record is an important factor in eliminating errors. The rapid growth in the amount of traffic handled by this system since it was established in January 1930 is indicated in Fig. 2.

## General Features

Briefly, the teletypewriter, or printer as it is sometimes called, is a machine which allows a message to be typed simultaneously in 2 or more remote locations. The connections between the various machines on a given network usually consist of ordinary telegraph circuits. If they are long, it may be necessary to provide terminal and intermediate telegraph repeaters in order to obtain satisfactory teletypewriter transmission.

In general, the teletypewriters as used for police communication are arranged to print the received message in page form. The typical machines of this type are shown in Fig. 1. It will be noted that some of the machines are equipped with keyboards while others are for receiving only, and therefore have no keyboards. Power for operating the various mechanisms is provided by fractional horsepower motors which take their current from the local a-c. or d-c. lighting circuits.

The layout of the private wire teletypewriter system of the New York state police is shown in Fig. 3. In this network there are at present 85 teletypewriter stations, 64 of which are arranged for both sending and receiving while 21 are equipped for receiving only. There are 6 switchboards located at the headquarters of the various state police troops. All but one of these switchboards are located in police barracks outside of metropolitan areas. The telegraph circuits involved in this network total about 3,500 miles and require 80 telegraph

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Based upon "Police Teletypewriter Communication" (No. 32M8) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932.

repeaters. Fig. 4 shows a typical telegraph office where provision is made for maintenance and supervision of such private wire systems. The circuit mileage is made up of various types of telegraph facilities, including the voice frequency carrier telegraph system, the metallic telegraph system, 2-path polar and one-way polar system, the polar duplex and the neutral system.

## TECHNICAL FEATURES

The essential elements of the teletypewriter system are: the sending mechanism, the telegraph line, and the receiving teletypewriter. By means of the sending mechanism, manually selected characters of the alphabet and certain necessary typewriter functions, such as paper feeding, carriage returning, and spacing, are converted into groups of electric impulses. These are transmitted over the telegraph circuit by means of different current values, which, as in practically all land line telegraph circuits, are of 2 values. (One of these current values may be zero as in the neutral telegraph system.) The signals set up the selecting devices in the receiving machine corresponding to the transmitted character, and cause this character to be reproduced.

The selecting code which is used employs 5 signal elements for each character. This 5-unit code, in combination with the possibility of either of 2 current values for each unit, provides 32 possible combinations. For instance, representing the 2 current values by (1) and (2) one of the 32 possible combinations would be 1-2-2-2-2. That is, the first unit would be transmitted at one current value and 4 following would be transmitted with the other current value. Another combination would be 1-2-2-2-1, etc.

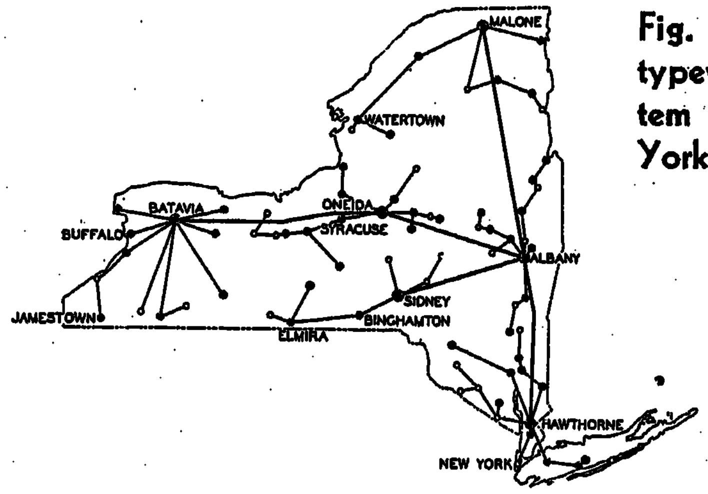

**Fig. 3. Teletypewriter system of the New York state police**

**Table I—Traffic on a Typical Police System in One Month**

| Type of Alarm | Statewide Broadcast | Local Harrisburg Zone Broadcast |
|---|---|---|
| Wanted for crime | 207 | 136 |
| Stolen automobiles | 1,254 | 0 |
| Other stolen property | 36 | 10 |
| Missing persons | 146 | 42 |
| Arrests of wanted | 39 | 38 |
| Miscellaneous | 99 | 543 |
| Recovered automobiles | 700 | 0 |
| Requests for information | 0 | 614 |
| Total | 2,481 | 1,383 |

One of the 5 unit combinations is assigned to each of the 26 letters of the alphabet, leaving 6 remaining for the teletypewriter functions, such as spacing, carriage returning, and paper feeding. Numerals and punctuation marks are obtained by providing 2 characters on each type-bar of the printing mechanism as in an ordinary typewriter, and one code combination is used for shifting from one set of characters to the other. The remaining, or 32nd, selecting combination is employed to allow a receiving station to "break" or stop the sending operator when that station wishes to send.

It of course is necessary to identify each of the 5 successive signal elements at the receiving end, in order that the proper selection be made. This is accomplished by having the receiving mechanism run in synchronism with the sending mechanism. This synchronizing is accomplished without unduly complicated mechanism, by means of the so-called start-stop principle which may be described briefly as follows:

The sending and receiving mechanisms each are driven by fractional horsepower motors running at approximately the same speed, the speeds being controlled either by governors or by the use of synchronous motors. These motors run continuously while the teletypewriters are in use, and through friction clutches drive the transmitting and receiving mechanisms. The transmitting and receiving mechanisms are restrained from operating, however, by mechanical arrangements which are released when the first line signal is received. In order to accomplish this starting function, the 5 selecting signal elements are preceded by a signal element of a current value opposite to that of the line in the idle condition. The receipt of this first signal at the receiving teletypewriter starts the printing cycle. The 5 selecting elements which follow the starting signal select the proper character and cause it to be printed. Following the selecting impulses a seventh signal element is transmitted over the line which causes the receiving mechanism to stop at the completion of the printing cycle. When the next group of signals is received, this cycle is

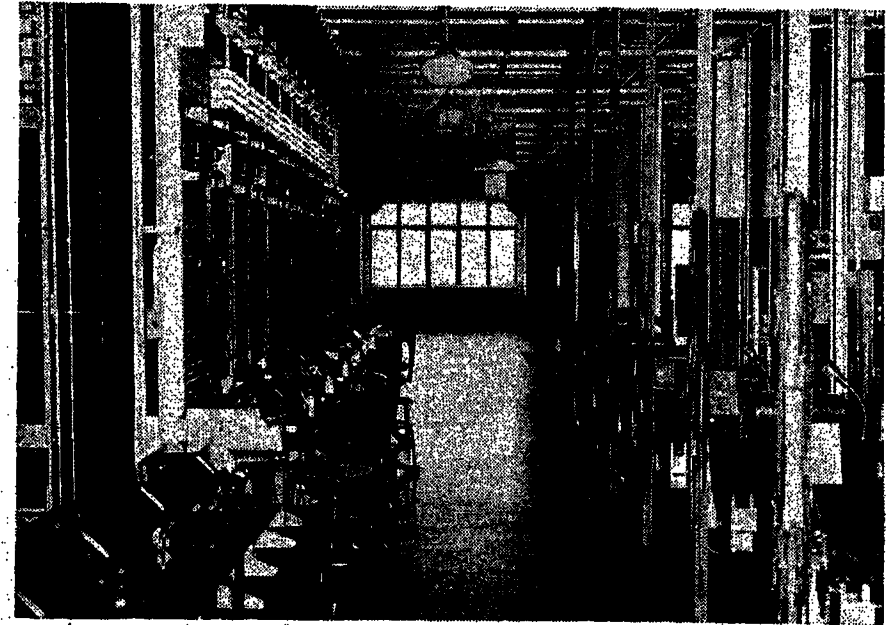

**Fig. 4. Typical repeater office for private wire teletypewriter systems**

repeated. With this arrangement the receiving mechanism does not start until the first impulse is received, and stops at the completion of the cycle. Therefore, the sending and receiving mechanisms are required to remain in synchronism for one printing cycle only. The teletypewriters usually are arranged to type at 60 words per min., or 6 letters per sec. The duration of a printing cycle, therefore, is approximately $^1/_6$ sec., and synchronism is accomplished without rigid requirements on the speeds of the teletypewriter motors.

In addition to simplifying the manner of maintaining synchronism, the start-stop principle makes it possible for 2 stations to communicate without regard to the distance between them or to the lag introduced in the telegraph signals by intervening circuits or apparatus. The selecting signal elements are always transmitted and received in the same time relation to the start impulse which controls the start of the printing cycle.

### SPECIAL FEATURES

Police teletypewriter systems have presented a number of special problems. One of these is due to the fact that the communications are of an intermittent nature, but service must be available continuously. It is therefore desirable that the calling station be able to start and stop the motors of all of the distant called stations. Therefore most police machines are so equipped that starting is accomplished by the sending of a "break" signal and stopping by the sending of a "shift" followed by an "H" signal from the teletypewriter keyboard.

By the use of "shift" signal followed by a letter signal, other features are made available. Teletypewriters thus are regularly provided with a signaling bell. Also in special cases, a loud ringing bell is provided, either a single stroke or a continuous alarm being used.

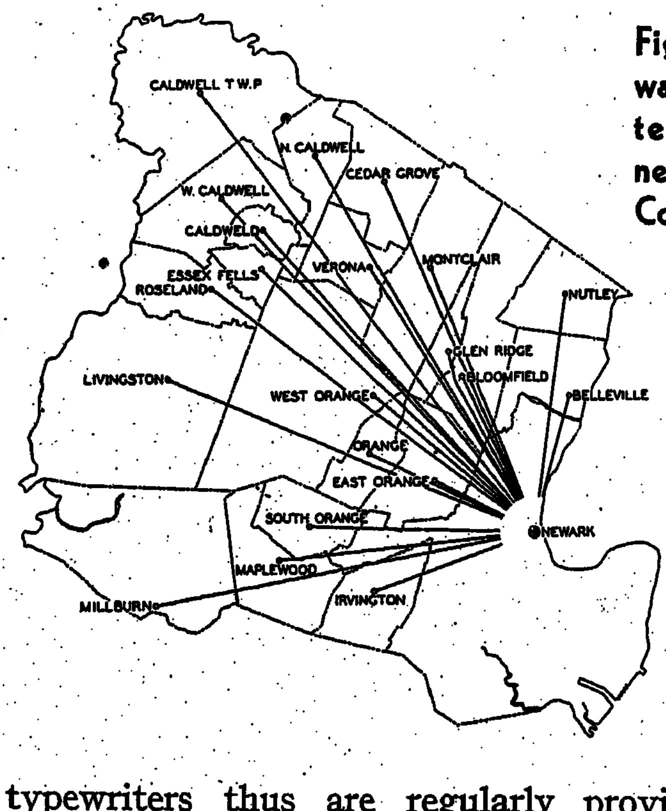

**Fig. 5. The one-way fixed layout teletypewriter network in Essex County, N. J.**

Some of the switchboards used in police systems are equipped with keys for switching, while others have cords and plugs of the type used in telephone switchboards. Since these switchboards are often located in remote places outside of metropolitan areas, it usually is necessary to provide a complete power plant to supply current for line facilities, supervisory signals, and teletypewriter machines.

In some statewide systems the stations are divided into zones, with each zone under the control of an individual switchboard. Arrangements may be provided which allow the operator at general headquarters to take control of the broadcasting circuit for any or all zones throughout the state, thus permitting the statewide broadcasting of certain alarms. The transferring of all the lines from the zone switchboard to sending relays under the control of the circuit from headquarters is accomplished by sending a code signal from a special key at general headquarters over the regular teletypewriter circuit to the zone headquarters. After the statewide broadcast, the circuit may be restored to normal by sending a long "break" signal from headquarters. These operations are accomplished without any action by operators at zone headquarters.

**Fig. 6. Teletypewriter installation at New York City police headquarters. Police Commissioner Edward P. Mulrooney is shown dictating a message during a recent 7,000-mile police teletypewriter hook-up covering the United States and Canada**

In some of the municipal networks, arrangements have been set up whereby a message or alarm sent to an outlying station equipped with a machine for receiving only, can be acknowledged. Usually, a separate circuit is provided for this purpose so that the operation of an acknowledgment key at the receiving station will give a signal, such as the lighting of a lamp at general headquarters. The attention of the receiving station operator may be attracted at the end of a message by the ringing of the teletypewriter bell at all receiving stations.

In a multi-station series network it sometimes is desirable to be able to select stations individually or in groups. For this purpose a selective calling arrangement using a regular telephone dial is used.

When the code number of a particular station is dialed, a selecting device at the station completes the power circuit, thereby starting the motor of the called station. A visible or audible signal will be operated to attract the attention of the operator at the called station, and a busy signal will be lighted at all other stations indicating that the circuit is busy. When desirable, a lock-out or secrecy feature may be provided which prevents any station not called from starting its machine and receiving the message being transmitted. This system has the obvious disadvantage that only one conversation at a time is possible on the network.

### Circuit Layout Features

Various types of circuits are adaptable to police teletypewriter systems. A few of these systems will be described briefly.

The one-way fixed layout system includes a central transmitting point from which communications are transmitted to a number of machines arranged for receiving only. An example of this type of system is shown in Fig. 5. The outstanding advantage of the one-way fixed layout system is the speed with which broadcasts can be made, since the entire network is always available.

The 2-way fixed layout system has all of the stations connected to the circuit so that any 1 can send and the others will receive. The outstanding advantage of this type of system is that the entire network is available to each station for broadcasting alarms or for intercommunication between individual stations. This system has the disadvantage that when 2 stations are communicating, the entire network is not available for a broadcast without interrupting the local conversation.

The one-way selective system consists of lines radiating from a switchboard at general headquarters with machines in the outlying points equipped for receiving only. This is similar to the one-way fixed layout system except that individual lines or groups of lines can be selected.

The 2-way selective switching system can be obtained in either one of 2 methods, or a combination of both. The first method is to provide a central switchboard with lines radiating out to each individual station. The second is to provide more than one station on each line, and to have these stations equipped with the selective calling devices mentioned previously. The advantages of this system are similar to those outlined in the 2-way fixed layout system, but the former has the added advantage that more than one conversation at a time can be carried on between stations in the network.

Many of the police teletypewriter systems combine the one-way and the 2-way features. The first statewide police system to be installed is operated by the state police of Pennsylvania and is of this type. Among other systems of this type is the one in New York City. Of this, the teletypewriter room at general police headquarters is shown in Fig. 6. The switchboard, which has direct lines to 33 precinct stations in Manhattan and to 4 others in borough headquarters, may be seen in the background.

### Exchange Service

When in November 1931 the telephone company offered teletypewriter exchange service to the public, the police departments of the country were among the first to avail themselves of this type of service. The exchange service provides switchboards and trunk line facilities for interconnecting teletypewriter stations at any place in the country. The police department subscribing to this service is provided with a teletypewriter machine with which it may call a teletypewriter exchange operator and obtain a connection with any other exchange teletypewriter station, whether this station is in the same city or in a distant city. This new service provides a nationwide system for interconnecting the various police departments in the country with the same type of record communication which has been so useful in the private wire systems.

# The Effects of Artificial Habits

**Views from a medical college dealing with the effects of engineering progress upon human life add another independent voice to the general discussion of benefits. This is the twelfth article in the Engineering Foundation's symposium, "Has Man Benefited by Engineering Progress?"**

By
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By building tents and huts, by covering the body with fur and cloth, primitive man was able to leave the cave, to expand into the open plain, and to survive in a colder climate; then protection against rain, cold, and storm was rendered complete with the invention of glass, which brought with it a new factor—comfort. All of these measures, first protective, then comfort producing, formed a continuous evolution which led to an artificial change of environment: From the straw apron to the modern apparel, from the primitive hut to the modern apartment house—an evolution which, when expressed biologically and physically, meant but a retreat from light into darkness and from ventilated atmosphere to stagnant air. Prejudices of fashion and custom have but served to fix the results of these developments and to render irreversible this crime against nature, this exclusion of natural stimuli to the skin. The penalty for this transgression is being paid.

### Light Starvation Favors Disease

Lack of ultraviolet rays, unless replaced by a high vitamin D diet, leads to rickets, tetany, and other ills, and predisposes strongly to infections, particularly pneumonia. Light starvation favors certain skin diseases, either directly from lack of stimulation or indirectly by breakdown of the vegetative nervous system and the absence of its coordinative action on the various powers of the body.

One important function of the skin is heat regulation. Heat must be conserved as much as possible in a cool environment, and strongly dissipated in a warm atmosphere. A complicated mechanism serves this purpose: Various stimuli from the skin and from the heat center of the brain affect the internal secretion, the blood chemistry, the blood capillaries of the skin and the sweat glands in such fashion that adaptation to the environment takes place. Operation of this mechanism represents a healthful physiological and psychological exercise for the body: It necessitates chemical and physical work; it requires a coordination of the efforts of the whole autonomic apparatus, which includes the nervous systems, the endocrines and the blood vascular system. The perfect working of this whole mechanism determines to a large extent a healthy constitution. By living in closed rooms and by dressing in heavy and tightly fitting garments, we have allowed this mechanism to cease functioning and its branches to degenerate. The result is that we cannot withstand even small variations of temperature, usually reacting with a cold to even the most moderate exposure. It is the fear of such exposure together with the dictates of fashion that have led the stronger sex so to overdress that their bodies constantly move in a tropical climate.

### Fashion and Science Conflict

Fashion and science now have reached the point where a break may occur unless fashion gives way. It should not be difficult to design a garment without a narrow collar and a tight belt, so that air ventilation is permitted. Disposing of vest and coat should not carry the stigma of social misdemeanor, but should be permitted as a means to allow the body to cool off, to admit some light and to increase its vitality. So long as our mode of dressing is not improved, I see no advantage in the use of windows made transparent to ultraviolet rays or in the use of ultraviolet lamps.

The great development, in recent times, of the building industry, of transportation, and of communication, with the resulting concentration of individuals within cities, schools, churches, theaters, trains, and street cars, has but served to strengthen the gregarious habit of man; this in itself has been shown by statistics to be the prime cause of the prevalence of infectious and contagious diseases. It is these very diseases which the medical man, the sanitary engineer, and the health director find so difficult to combat. That these effects are being realized is evidenced by the efforts of theater owners toward ventilation and temperature regulation of their theaters, and by the increased tendencies of the people to abandon the narrow confines of the city for the more open territory of the suburb. These tendencies have been abetted by the privacy and quickness of the automobile and by the comfort of the radio, together with coming television.

The invention of the machine, followed by its constant modification and improvement to meet the various needs of today, has increased a hundred fold the means for comfort and lessened human labor, and has been heralded as a welcome means to lighten the burden of man. But now the pendulum having swung in the prophesied direction, we have gone from the frying pan into the fire; from the dilemma of too much work we have entered into the morass of idleness. The politician of today has failed to find a remedy for this situation, so let us turn to the views of the biologist.

### Views of a Biologist

In his book, "Studies on Human Biology," Pearl devotes one chapter to the influence of physical activity upon mortality. He bases his deductions on English statistics on the mortality of occupied males more than 15 yr. of age. He divides the 132 occupations into indoor and outdoor work and each of these into 5 groups of increasing activities, from light to hard work. After discussing and eliminating most of the possible sources of error he comes to the following conclusions:

1. Light, medium, and heavy work cause no difference of the death rate between the ages of 15 and about 45 yr. From 45 yr. on, however, hard work increases the death rate, with a strongly increasing ratio for the higher ages. This makes it evident that "before age 40 is attained, it makes no difference in the rate of mortality, whether the occupation involves light or heavy physical labor. After about age 45 it appears that a man shortens his life by definite amounts in proportion as he performs physically heavy labor."
2. Mortality is distinctly lower for outdoor than for indoor workers. This indicates the superior healthfulness of outdoor life.

I should like to add a few generally accepted premises upon which to base a few suggestions of an important social bearing:

1. Work is healthful, mentally and physically, for men and women between 17 and about 45 yr.
2. Many modern professions require too much sedentary life and need outdoor recreation for compensation.
3. Most professions are monotonous; therefore their dulling effects upon the mind should be overcome by recreation that provides mental exercise.

### Better Regulation of Work Needed

Assuming the correctness of these premises one easily recognizes that, because of leaving work and idleness distributed at random, the present system of unrestricted labor and unrestricted unemployment is the incorrect answer to this problem. The only logical measure is to regulate work so much that every man or woman from 17 or 18 up to 45 or 50 yr. old can be provided with work. A 5-day week and a 6-hr. day would suffice for the needs of most countries. The rest of the time can be devoted to healthful recreation. This regulation should be revised periodically according to variations caused by seasons and business cycles. The sick and the old should be protected from destitution by compulsory invalid insurance and old age pensions, or else given a chance to accumulate enough capital to meet such contingencies.

I am convinced that in the adoption of such a scheme lies the opportunity to eliminate the disadvantages of mechanization, and to utilize its benefits in such a fashion as to enable us to live agreeable, healthy lives in greater conformance with the rules of nature and the teachings of modern medicine. It is to be hoped that the present depression will serve as an impetus to give it a trial.

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**Editor's Note: Pursuant to the invitation of the Engineering Foundation, the editors will be happy to receive comments, criticisms, or discussions pertaining to this or other articles published in this series.**

# Analysis of Equivalent Circuits

**Analysis of various circuit problems may be facilitated by the substitution of equivalent circuits which reduce the complexity and permit the replacing of magnetic coupling with simple impedance links so that the calculating board may be used for solution. In this article, general methods of solving the transformer, network, and zero phase sequence problems are presented along with useful diagrams and equations for particular cases.**

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EQUIVALENT circuits are used in the analysis of certain circuit problems. The method consists of replacing the magnetic or electrical system to be analyzed with a simplified equivalent linkage of simple impedance links which satisfies the same terminal conditions. In general, any problem which can be analyzed with an equivalent circuit can be analyzed without it. However, the equivalent circuit may be useful for any or all of the following reasons:

1. Since the equivalent circuit represents only terminal conditions, it is frequently simpler than the actual machine or circuit.
2. The use of the equivalent circuit speeds up and systematizes calculation, in some cases reducing the amount of calculation.
3. The equivalent circuit aids in visualizing the problem.
4. Since the equivalent circuit is made up of simple impedance links, it may be set up readily on the calculating board, thereby lending itself to the solution of complicated networks.

Three closely related types of problems present themselves; namely, the transformer problem, the network problem, and the zero phase sequence system problem. This latter arises primarily through the difficulty experienced in adequately representing on the calculating board, groups of parallel transmission lines in which zero phase sequence currents are flowing. To represent such a group it is desirable to replace it with an equivalent circuit in which mutual impedances between the lines are simulated by simple impedance links. The method of determining such an equivalent circuit is presented in this article following a discussion of the first two types of problems.

The two generalized equivalents discussed under the first two problems are quite broad and should find many applications other than those cited. Only linear circuits and networks are dealt with, however, and in general the circuits developed are equivalent only at a single frequency, although certain ones such as in Figs. 7, 8, and 10 to 13, are equivalent at all frequencies.

## THE TRANSFORMER PROBLEM

In practise, the multi-circuit problem, that is, the problem of a number of circuits each having a self-impedance and a mutual impedance with every other circuit, frequently presents itself. It is usually desired to determine the current in each branch, having given the voltage impressed across each circuit. If the calculating board is to be used in the solution of such problems, the system of coupled circuits must be replaced by an equivalent linkage, since magnetic coupling of adequate flexibility usually cannot be simulated on the calculating board.

Equivalent circuits for the relatively simple case of the two-winding transformer are shown in Fig. 1. In the conventional equivalent circuit of Fig. 1(*b*) all impedances must be expressed on a common voltage

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Based upon "Equivalent Circuits—I" (No. 32-21) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932.

base since the same current flows in each. If $\alpha$ is the ratio of primary to secondary turns, then the values of $Z_1$ and $Z_2$ referred to the primary are, in terms of the magnetizing and mutual impedances (called the characteristic $A$ coefficients):

$$Z_1 = A_{11} - A_{12}a \quad (1)$$

$$Z_2 = A_{22}a^2 - A_{12}a \quad (2)$$

Similar circuits have been developed for the three-winding transformer and the double-winding generator, the value of this type of circuit being discussed in "Theory of Three-Circuit Transformers," by A. Boyajian, A.I.E.E. TRANS., v. 43, 1924, p. 508–29. In the same paper the general equations for setting up a similar type of circuit for the $n$-winding transformer are written. The equivalent circuit of Fig. 1($c$) while still not strictly correct, represents more nearly the actual transformer. In this circuit the short-circuit impedance of the primary is

$$Z = \frac{A_{11}A_{22} - A_{12}^2}{A_{22}} \quad (3)$$

A general equivalent circuit for the $n$-winding transformer having $2n$ points of entry has been derived. This circuit is a mesh composed of $n(2n - 1)$ impedance links, one connecting each point of entry with every other point of entry. The impedance of the link connecting the two points of entry of some winding $j$, i. e., points $j$ and $j'$, is the driving point impedance from point $j$; and the link connecting two points of entry of two different windings, say points $j$ and $k'$ of windings $j$ and $k$, is equal to the transfer impedance between points $j$ and $k'$. These link impedances may be measured directly or calculated from known transformer constants, the $A$ coefficients.

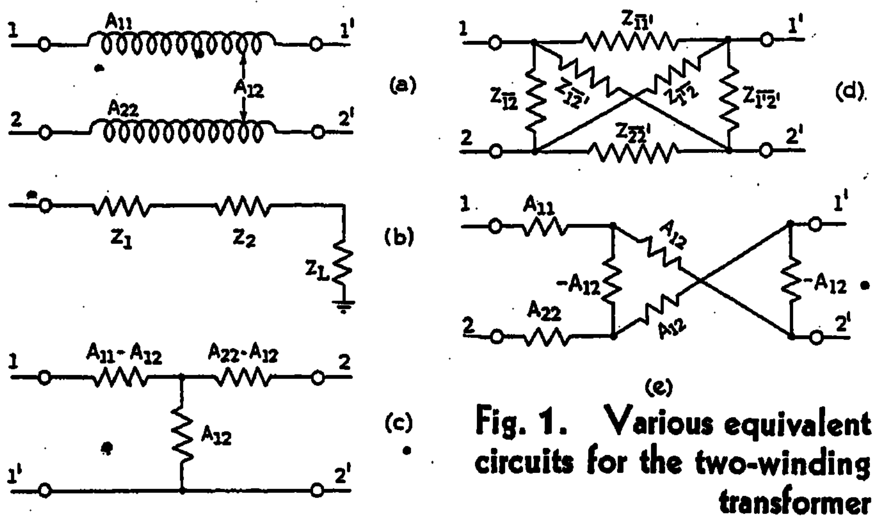


**Fig. 1. Various equivalent circuits for the two-winding transformer**

($a$) The two-winding transformer, in which $A_{11}$ is the primary self-impedance or magnetizing impedance, $A_{22}$ is the secondary impedance, and $A_{12}$ is the mutual impedance between the windings

($b$) Conventional equivalent circuits used for calculating regulation, magnetizing current being neglected. This circuit gives no voltage transformation. $Z_1$ is primary leakage impedance (resistance plus leakage reactance), $Z_2$ is secondary leakage impedance, and $Z_L$ is load impedance, all expressed on a common voltage base

($c$) Equivalent circuit which gives voltage transformation and does not neglect magnetizing current. This circuit must be viewed from one winding only, since it falls down when viewed as a four point network

($d$) A rigorous equivalent for the two-winding transformer which cannot be distinguished from the actual transformer under any imposed terminal conditions

($e$) An equivalent equally as rigorous as that of the Fig. 1(d), but much simpler

The general equivalent circuit for the two-winding transformer is shown in Fig. 1($d$) and is seen to consist of a six-link mesh, the values of which are

$$Z_{\overline{11'}} = \frac{A_{11}A_{22} - A_{12}^2}{A_{22}} \quad (4)$$

$$Z_{\overline{22'}} = \frac{A_{11}A_{22} - A_{12}^2}{A_{11}} \quad (5)$$

$$Z_{\overline{12}} = \frac{A_{11}A_{22} - A_{12}^2}{A_{12}} \quad (6)$$

$$= Z_{\overline{1'2'}} = -Z_{\overline{12'}} = -Z_{\overline{1'2}}$$

Equations defining the links for the equivalent mesh to represent the $n$-winding transformer shown in Fig. 2 have been derived and are as follows:

$$Z_{\overline{kk'}} = \frac{1}{B_{kk}} \quad (7)$$

$$Z_{\overline{jk'}} = \frac{1}{B_{jk}} = Z_{\overline{j'k}} = -Z_{\overline{j'k'}} = -Z_{\overline{jk}} \quad (8)$$

where $B_{kk}$ is the driving point admittance from point $j$, $B_{jk}$ is the transfer admittance between points $j$ and $k$, and $Z_{jk}$ is the impedance of the link connecting any two points of entry $j$ and $k$. The values of these links for the general case may be calculated or measured directly at the terminals of the transformer. The method of measuring transfer and driving-point impedances is well known. The $B$ coefficients are defined by and may be calculated from the following determinantal relations:

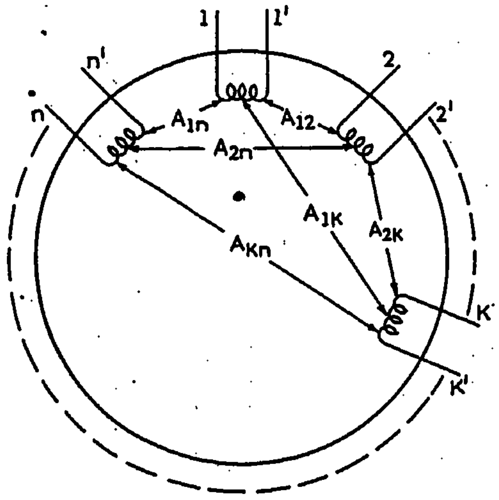


**Fig. 2. A system of $n$ electrically isolated but magnetically coupled circuits**

Such a system may be replaced by an equivalent mesh of $n(2n - 1)$ links connecting each of the $2n$ points of entry in all possible ways. For example of equivalent mesh when $n = 2$, see Fig. 1($d$)

$$B_{jk} = B_{kj} = \frac{Q_{A-jk}}{\Delta_{n-A}}(-1)^{j+k} \quad (9)$$

where

$$\Delta_{n-A} = \left\{ \begin{matrix} A_{11}\, A_{12} \ldots . A_{1n} \\ \cdot \\ A_{k1}\, A_{k2} \ldots . A_{kn} \\ \cdot \\ A_{n1}\, A_{n2} \ldots . A_{nn} \end{matrix} \right\} \quad (10)$$

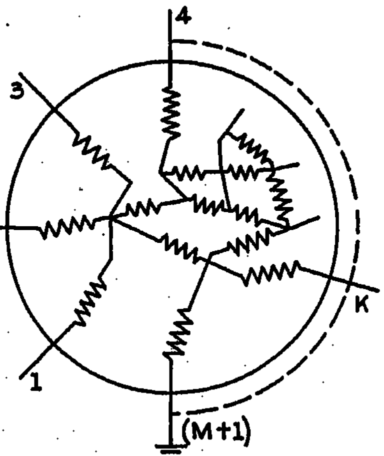
and $Q_{A-jk}$ is the cofactor of $A_{jk}$ in $\Delta_{n-A}$ (i. e., the minor of $\Delta_{n-A}$ with the $j$'th column and $k$'th row deleted) the sign of which is $(-1)^{j+k}$.

The equivalent circuit of Fig. 1(*e*) is seen to be a combination mesh and star arrangement, and may be arrived at by simple reasoning from the mesh of Fig. 1(*d*). Since the self-impedance of any winding is independent of the other windings, its value need not appear in any of the mutual links if it be lumped as a radial link at the terminals of the circuit. Thus, setting $A_{11}$ and $A_{22}$ equal to zero in eqs. 4, 5, and 6, and inserting radial links having impedances equal to $A_{11}$ and $A_{22}$ in terminals 1 and 2, respectively, one will obtain the circuit of Fig. 1(*e*). This latter circuit is much more useful than that of Fig. 1(*d*) since the mutual links are purely reactive, the resistances appearing only in the terminal links. This arrangement avoids the possibility of negative resistance appearing in any link. In an entirely similar manner the mesh equivalent of any number of coupled circuits may be simplified and rendered more useful by reducing to a combination star-mesh arrangement.

## THE NETWORK PROBLEM

In the study of the behavior of a large transmission and distribution system, the transmission lines and connected apparatus commonly are represented by an appropriate single-line diagram, all units of connected equipment being replaced with suitable impedance links. In most cases no trouble is experienced in mapping out the single-line diagram, at least none for the positive and negative phase sequence diagrams, since standard methods are available for doing this.

In setting up the single-line diagram on the calculating board, for purposes of simplification it may be desirable to replace either the whole system or some section of it with an equivalent impedance mesh which has the same number of points of entry but a greatly reduced number of links. For example, Fig. 3 shows a complicated network of impedance links having $(m + 1)$ points of entry. Such a network may be replaced with an equivalent mesh having $\frac{m(m+1)}{2}$ links, one connecting each point of entry with every other point of entry. The equivalent mesh for a five-point network is shown in Fig. 4 (note that $m = 4$ and that for purposes of analysis the $m + 1$ point is considered as a ground point).



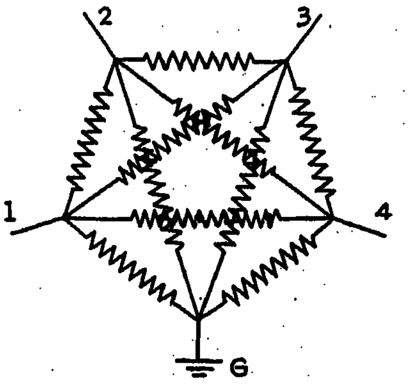


**Fig. 3. (Left) A general network, not simplified**

**Fig. 4. (Right) Equivalent mesh for a network having five points of entry**

The values of the links of the equivalent mesh which is to replace the general network may be determined either by direct calculation from the network constants or by measurements made at the terminals of the network. It may be shown that the impedance of the link connecting any two points of entry such as $j$ and $k$ is equal to the transfer impedance between the points $j$ and $k$, i. e.,

$$Z_{\overline{jk}} = Z_{jk} \tag{11}$$

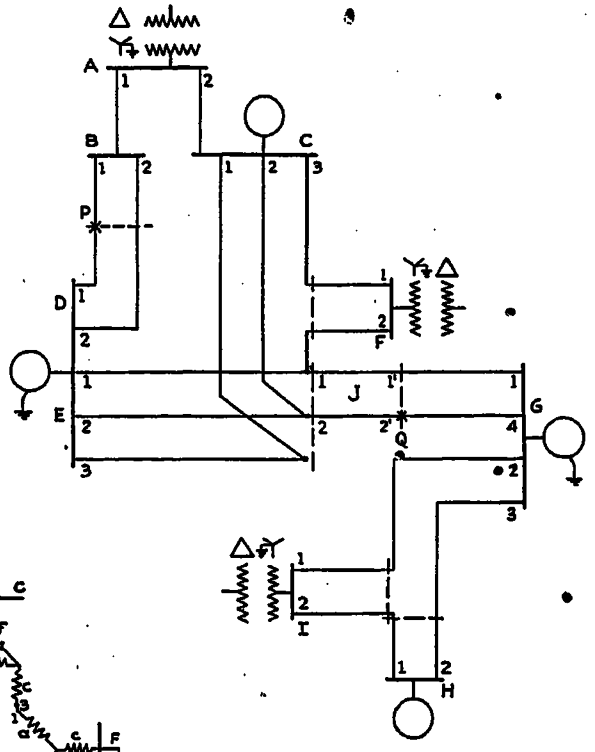


**Fig. 5. (Right) Single-line diagram of a transmission system**

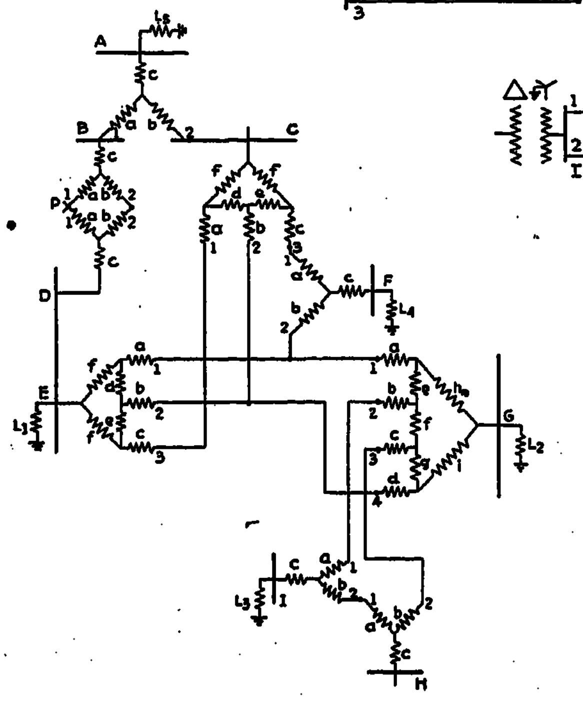


**Fig. 6. (Left) Equivalent circuit for the zero phase sequence diagram of the system shown in Fig. 5 for a ground fault at point *P***

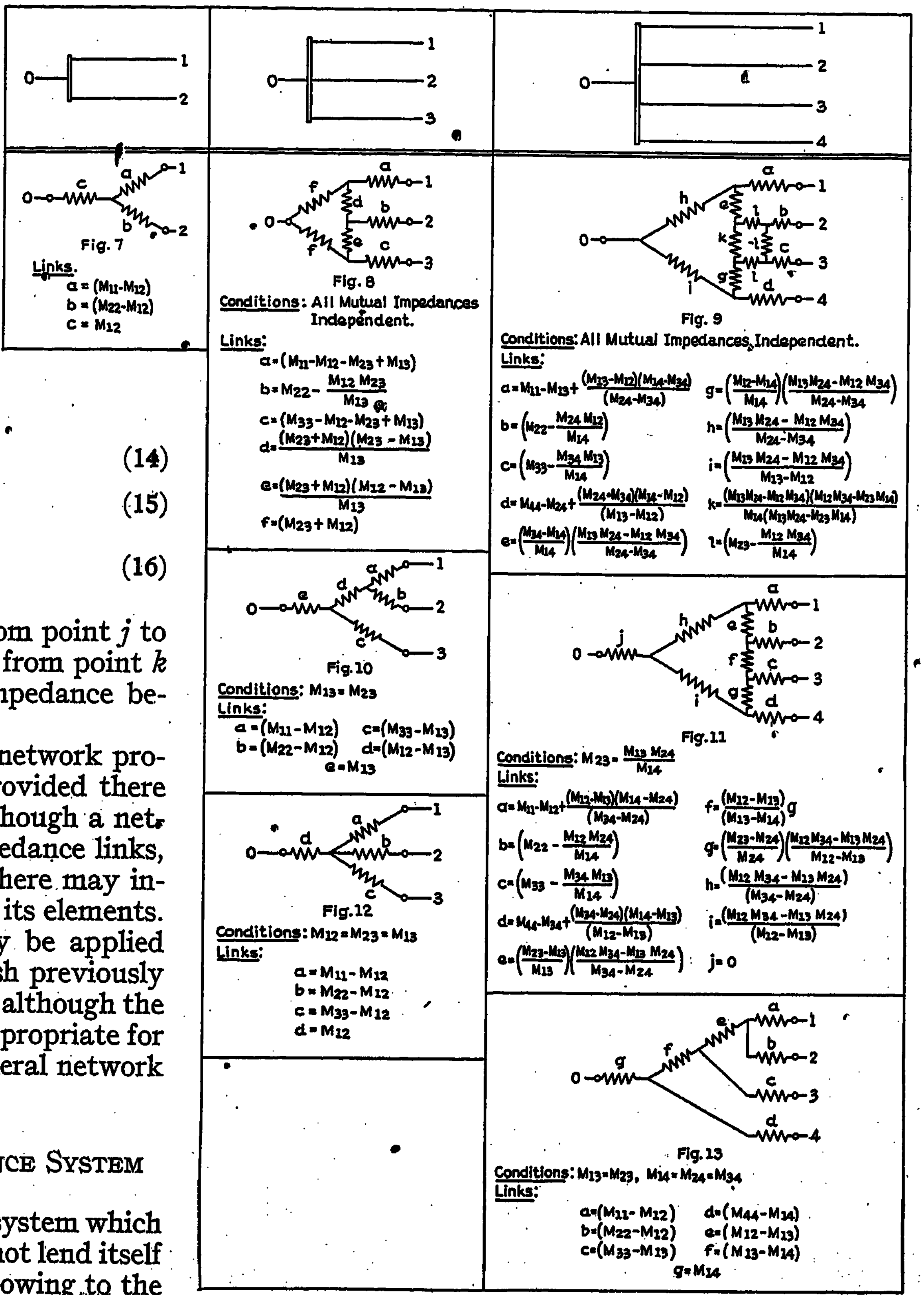
The impedances of the links of the equivalent mesh may be calculated by determinants in terms of the through impedances of the network (by through impedance between any two points such as $j$ and $k$ is meant the impedance between these points with all other points open).

It may be shown that

$$Z_{\overline{jk}} = \frac{\Delta_{m-c}}{Q_{c-jk}} \tag{12}$$

where

$$\Delta_{m-c} = \left\{\begin{matrix} C_{11}C_{12}\ldots\ldots C_{1m} \\ \cdot \\ C_{k1}C_{k2}\ldots\ldots C_{km} \\ \cdot \\ C_{m1}C_{m2}\ldots\ldots C_{mm} \end{matrix}\right\} \tag{13}$$



**Figs. 7–13. From these diagrams, equivalent circuits may be obtained to represent various groups of parallel transmission lines such as shown in Fig. 5 when the zero phase sequence diagram is to be set up on the calculating board**

Fig. 7

Links.

$a = (M_{11}-M_{12})$

$b = (M_{22}-M_{12})$

$c = M_{12}$

Fig. 8

Conditions: All Mutual Impedances Independent.

Links:

$a=(M_{11}-M_{12}-M_{23}+M_{13})$

$b=M_{22}-\frac{M_{12}M_{23}}{M_{13}}$

$c=(M_{33}-M_{12}-M_{23}+M_{13})$

$d=\frac{(M_{23}+M_{12})(M_{23}-M_{13})}{M_{13}}$

$e=\frac{(M_{23}+M_{12})(M_{12}-M_{13})}{M_{13}}$

$f=(M_{23}+M_{12})$

Fig. 9

Conditions: All Mutual Impedances Independent.

Links:

$a=M_{11}-M_{13}+\frac{(M_{13}-M_{12})(M_{14}-M_{34})}{(M_{24}-M_{34})}$

$b=\left(M_{22}-\frac{M_{24}M_{12}}{M_{14}}\right)$

$c=\left(M_{33}-\frac{M_{34}M_{13}}{M_{14}}\right)$

$d=M_{44}-M_{24}+\frac{(M_{24}-M_{34})(M_{14}-M_{12})}{(M_{13}-M_{12})}$

$e=\left(\frac{M_{34}-M_{14}}{M_{14}}\right)\left(\frac{M_{13}M_{24}-M_{12}M_{34}}{M_{24}-M_{34}}\right)$

$g=\left(\frac{M_{12}-M_{14}}{M_{14}}\right)\left(\frac{M_{13}M_{24}-M_{12}M_{34}}{M_{24}-M_{34}}\right)$

$h=\left(\frac{M_{13}M_{24}-M_{12}M_{34}}{M_{24}-M_{34}}\right)$

$i=\left(\frac{M_{13}M_{24}-M_{12}M_{34}}{M_{13}-M_{12}}\right)$

$k=\frac{(M_{13}M_{24}-M_{12}M_{34})(M_{12}M_{34}-M_{23}M_{14})}{M_{14}(M_{13}M_{24}-M_{23}M_{14})}$

$l=\left(M_{23}-\frac{M_{12}M_{34}}{M_{14}}\right)$

Fig. 10

Conditions: $M_{13}=M_{23}$

Links:

$a=(M_{11}-M_{12})$ $c=(M_{33}-M_{13})$

$b=(M_{22}-M_{12})$ $d=(M_{12}-M_{13})$

$e=M_{13}$

Fig. 11

Conditions: $M_{23}=\frac{M_{13}M_{24}}{M_{14}}$

Links:

$a=M_{11}-M_{12}+\frac{(M_{12}-M_{13})(M_{14}-M_{24})}{(M_{34}-M_{24})}$

$b=\left(M_{22}-\frac{M_{12}M_{24}}{M_{14}}\right)$

$c=\left(M_{33}-\frac{M_{34}M_{13}}{M_{14}}\right)$

$d=M_{44}-M_{34}+\frac{(M_{34}-M_{24})(M_{14}-M_{13})}{(M_{12}-M_{13})}$

$e=\left(\frac{M_{23}-M_{13}}{M_{13}}\right)\left(\frac{M_{12}M_{34}-M_{13}M_{24}}{M_{34}-M_{24}}\right)$

$f=\frac{(M_{12}-M_{13})}{(M_{13}-M_{14})}g$

$g=\left(\frac{M_{23}-M_{24}}{M_{24}}\right)\left(\frac{M_{12}M_{34}-M_{13}M_{24}}{M_{12}-M_{13}}\right)$

$h=\frac{(M_{12}M_{34}-M_{13}M_{24})}{(M_{34}-M_{24})}$

$i=\frac{(M_{12}M_{34}-M_{13}M_{24})}{(M_{12}-M_{13})}$

$j=0$

Fig. 12

Conditions: $M_{12}=M_{23}=M_{13}$

Links:

$a=M_{11}-M_{12}$

$b=M_{22}-M_{12}$

$c=M_{33}-M_{12}$

$d=M_{12}$

Fig. 13

Conditions: $M_{13}=M_{23}$, $M_{14}=M_{24}=M_{34}$

Links:

$a=(M_{11}-M_{12})$ $d=(M_{44}-M_{14})$

$b=(M_{22}-M_{12})$ $e=(M_{12}-M_{13})$

$c=(M_{33}-M_{13})$ $f=(M_{13}-M_{14})$

$g=M_{14}$

and $Q_{c-jk}$ is the cofactor of $C_{jk}$ in $\Delta_{m-c}$. The characteristic coefficients of the above determinants in terms of the through impedances of the network are:

$$Z_{jj} = Z_{j-0} \tag{14}$$

$$C_{kk} = Z_{k-0} \tag{15}$$

$$C_{jk} = \frac{Z_{j-0} + Z_{k-0} - Z_{j-k}}{2} \tag{16}$$

where $Z_{j-0}$ is the through impedance from point $j$ to ground, $Z_{k-0}$ is the through impedance from point $k$ to ground, and $Z_{j-k}$ is the through impedance between points $j$ and $k$.

These methods apply to any general network provided the impedances are linear and provided there are no internal voltages. Note that although a network usually is composed of simple impedance links, the general network as it is considered here may involve magnetic coupling between any of its elements. In fact the general network mesh may be applied directly in obtaining the equivalent mesh previously discussed for the $n$-winding transformer, although the latter mesh is much simpler and more appropriate for the transformer problem than is the general network mesh.

## DIAGRAM OF THE ZERO PHASE SEQUENCE SYSTEM

The zero phase sequence diagram of a system which involves parallel transmission lines does not lend itself so readily to a calculating board set up, owing to the fact that when zero phase sequence currents are flowing in the parallel lines, the mutual magnetic coupling between them cannot be neglected; neither can it be represented adequately by the usual calculating board equipment.

A typical example of a system involving groups of parallel lines is shown in Fig. 5. The analytical determination of the currents in every branch of this system due to a ground fault practically is impossible, but if each group of parallel lines is replaced with an equivalent linkage, the calculating board may be applied to obtain an exact solution.

A group of circuits representing two, three, and four parallel lines under various conditions is shown in Figs. 7 to 13, inclusive. Since more than four parallel lines seldom exist for any great distance, equivalents for groups of more than four lines have not been derived; however, should a case arise in which more than four parallel lines do occur, appropriate circuits readily may be developed.

In regard to this special group of equivalents for parallel lines it should be noted that:

1. The values of impedance links are short usable expressions in terms of the self-impedances and mutual impedances of the lines, which are constants usually known.

2. Negative impedance links usually may be avoided in the application of these circuits (the circuits of Fig. 9 being excepted) thereby permitting the use of the d-c. calculating board where resistance may be neglected.

3. The self-impedance of each line appears only in the radial link at the terminal, the mutual links being purely reactive. This arrangement insures that negative resistance will always be avoided.

To illustrate the utility of these special circuits, the system of Fig. 5 is shown in an equivalent form in Fig. 6. Here each group of parallel lines is replaced with an appropriate equivalent. Note that the links of these equivalent circuits are all expressed in terms of the self-impedances and mutual impedances of the lines, $M_{jj}$ being the self-impedance of line $j$ and $M_{jk}$ being the mutual impedance between lines $j$ and $k$. These coefficients are usually known, and if not, they may be readily measured or calculated. The set-up of Fig. 6 may be placed upon the calculating board and used for determining the magnitude and distribution of ground-fault currents for various fault locations, as, for example, at some point $P$, or on any bus.

# Concentration of Heating Currents

**The proximity effect, usually considered as undesirable and wasteful, may be used to concentrate heating currents in predetermined strips of conducting bodies. Both the current density and shape of the strip may be so controlled as to make this method valuable in a number of heating processes.**

By
**EDWARD BENNETT**
FELLOW A.I.E.E.

University of Wisconsin, Madison

ELECTRIC heating currents frequently are used in industrial operations such as welding, forming, and hardening. Where it is desired that the heating be confined to predetermined strips of the conducting bodies, the "proximity" effect may be utilized to control the path of the heating current.

The "proximity" effect, as it is called, is the redistribution of the current densities over the cross-section of conductors which occurs when 2 conductors at first remote from each other are brought into close proximity. Currents flowing in opposite directions in two such conductors cause the current density in the closely adjacent filaments of the conductors to be higher than in the more remotely separated filaments. The less the separation of the conductors and the higher the frequency, the greater will be the variation of the current density. This effect may be magnified to serve a very useful purpose in many industrial heating operations.

Bibliographies of the literature dealing with the distribution of current densities over the cross-section of conductors will be found at the end of the following papers: "Experimental Researches on Skin Effect in Conductors," A. E. Kennelly, F. A. Laws, P. H. Pierce, A.I.E.E. TRANS., v. 34, 1915, p. 1953–2018; and "Bessel Functions for Alternating Current Problems," H. B. Dwight, A.I.E.E. TRANS., v. 48, 1929, p. 820. The second bibliography contains references to papers appearing since the preparation of the first.

The confining of the heating currents to predetermined strips is accomplished by using currents of a frequency in the range known as the audio range, and by the electrical connections and space arrangements illustrated in Figs. 1 to 6. An examination of these arrangements will show that they may be grouped under the following classifications:

1. Current conductively conveyed to the body to be heated.
   a. The shapes and the connections of the heated bodies alone determine the strips in which the current concentrates. See Figs. 1, 2, and 3.
   b. An auxiliary water-cooled conductor is used to determine the strips of concentration. See Figs. 4 and 5.

2. The current is induced in the strip to be heated. A tubular water-cooled inducing coil lies in close proximity to the strip and there is no conductive connection with the body to be heated. See Fig. 6.

In each diagram, the transformer symbol represents the source of audio frequency current. The arrows represent the directions of the currents at a given instant of time. For the sake of clearness it has been necessary to draw the parts with considerable distance between the adjacent edges; but in the actual equipment, this gap is of the order of a few millimeters or centimeters, depending upon the thickness of the edges. The heating currents may be confined to layers ranging in depth from a few millimeters to several centimeters.

The first sight of the red-hot strip of steel conforming to the sinuosities of the water-cooled copper tube mounted above the steel plate illustrated in Fig. 5 is found to be somewhat startling even to engineers who have witnessed the heating effects obtained with the arrangements shown in Figs. 1, 2, and 3.

In all of the arrangements illustrated in these figures, the control over the pattern according to which the current densities are to decrease from the center line to the edges of the selected strip and from the surface of the strip to the interior of the body is had by the joint adaptation of 3 things; namely, the frequency of alternation of the heating currents,

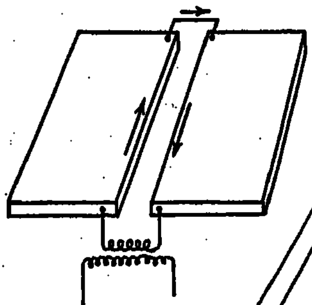


Fig. 1

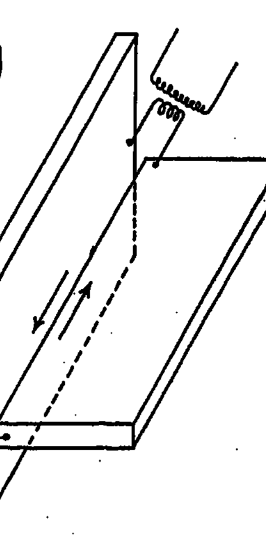


Fig. 2

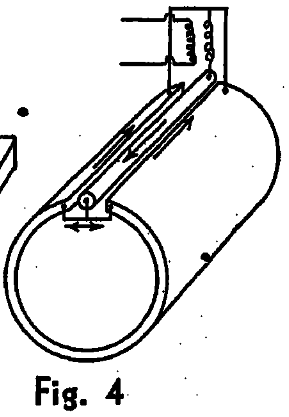


Fig. 4

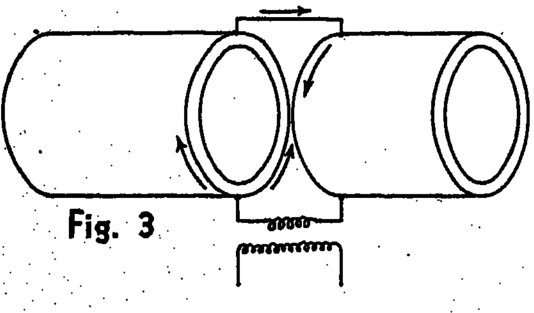


Fig. 3

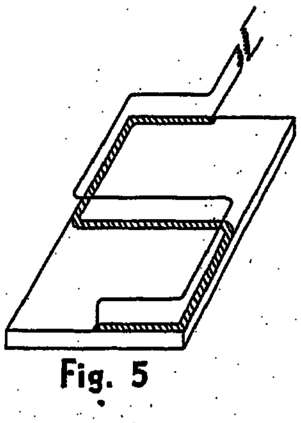


Fig. 5

Fig. 1. Connections for heating edges of plates
Fig. 2. Connections for heating an edge and a strip
Fig. 3. Connections for heating ends of pipes
Figs. 4 and 5. Connections for an auxiliary conductor which determines the path of the heating current

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Based upon "The Proximity Effect, Its Application to the Concentration of Heating Currents in Predetermined Strips" (No. 32-54) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932.

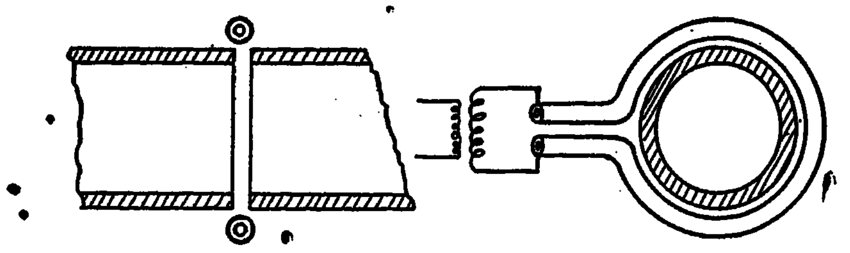

Fig. 6. Strip heating by an inducing coil

Table I—Values of the Penetration Unit

| Material | Temp. °C. | Relative Resistivity | Relative Permeability | Frequency | Conductivity mho-cm. | P. unit cm. |
|---|---|---|---|---|---|---|
| Copper | 20 | 1 | 1 | 960 | 580,000 | 0.214 |
| Steel | 20 | 11 | 100 | 960 | 52,700 | 0.070 |
| Steel | 800 | 94 | 1 | 960 | 6,240 | 2.06 |
| Steel | 1,300 | 100 | 1 | 960 | 5,800 | 2.14 |
| Earth | | $5.8 \times 10^9$ | 1 | 60 | $10^{-4}$ | 65,000 |

the distance from the surface of the strip to the second conductor, and the width and cross-sectional shape of this second conductor. A high-frequency, a short distance between the surface of the strip to be heated and the second conductor, and a narrow second conductor lead to the concentration of the heating current in a narrow strip.

In dealing with the distribution of alternating currents over the cross-section of conducting bodies, it is very helpful to express all linear dimensions, not in centimeters but in terms of a unit of length appropriate to this problem. This unit of length may be called the "penetration unit" for the material at the frequency in question. The advantage of using this unit is that it makes possible the representation, by a few curves, of the distribution of the current for a wide range of conducting materials, spacings, and frequencies.

The length of the penetration unit is,

$$1\ P \text{ unit (penetration unit) (in cm.)} = \frac{1}{\sqrt{\pi f \mu \gamma}} \qquad (1)$$

where

$f$ represents the frequency

$\gamma$ represents the conductivity of the conductor in mho-cm.

$\mu$ represents the permeability of the conductor in weber ampere-turn cm. units. ($\mu = 4\pi 10^{-9}$ for non-magnetic materials.)

The values of the penetration unit for different materials and frequencies are as shown in Table I.

In order that a physical significance may attach to the penetration unit as defined in eq. 1, the following statements may be noted. The effective resistance to an alternating current of frequency $f$ of a conductor of circular cross-section, the radius of which is 5 or more times the penetration unit of the material at the frequency $f$, is approximately equal to the ordinary ohmic resistance of a surface layer of the conductor having a depth equal to the penetration unit. Again, at a depth of 1 penetration unit below the surface of such a large conductor, the current density is approximately 36.8 per cent of the density at the surface, and it lags by 1 radian behind the current density at the surface.

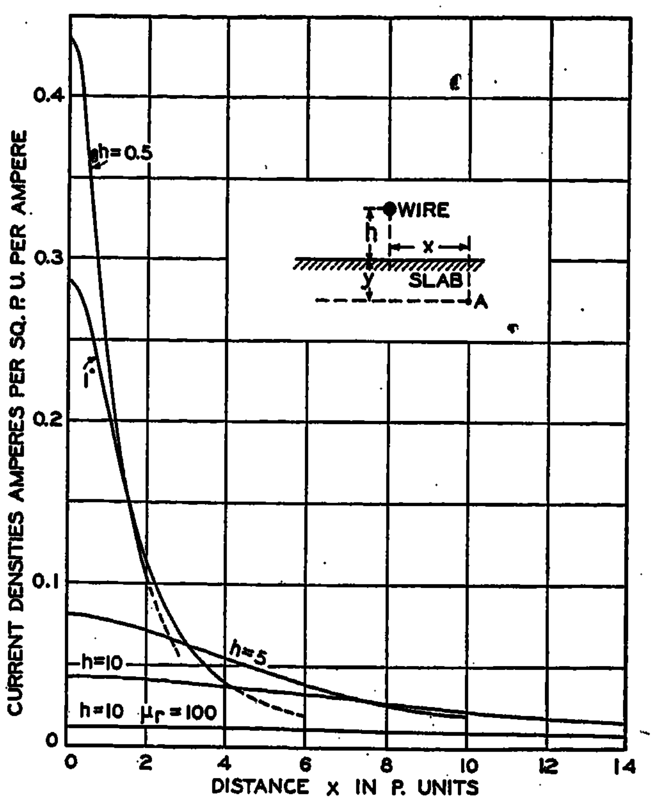

Fig. 7. Current densities at the surface of a slab for different mounting heights

Current densities are expressed in amperes per sq. penetration unit per ampere of heating current flowing in the auxiliary conductor. The distances $x$ and $h$ are expressed in penetration units

To illustrate the extent to which heating currents can be caused to concentrate in narrow strips by enhancing the proximity effect, the current densities have been worked out and plotted for the arrangement illustrated in Fig. 5, except that the auxiliary conductor has no sinuosities but is in the form of a long straight wire mounted over a wide conducting slab of a thickness 5 or more times the penetration unit of the material at the operating frequency. The radius of the auxiliary conductor has been assumed to be very small in comparison with its mounting height, $h$, say 5 per cent or less.

The current density $C$ at any point $A$ in the slab may be computed from the following Fourier integral.

$$C = \frac{j\,2\,I}{\pi} \int_0^\infty \frac{1}{\sqrt{b^2 + 2j} + b\mu_r} \cos xb \exp(-\,hb - y \sqrt{b^2 + 2j})db \qquad (2)$$

where

$C$ represents the current density at $A$ in amperes per sq. Pen. unit

$b$ represents the variable of the integrand. It disappears from the integral upon substituting the two limits 0 and $\infty$

$I$ represents the value of the heating current in amperes

$h$ represents the height of the auxiliary conductor above the surface

$y$ represents the depth of the point $A$ below the surface

$x$ represents the $x$ coordinate of the point $A$, as shown in Fig. 7

$\mu_r$ represents the relative permeability of the conducting slab

$j$ represents $\sqrt{-1}$

exp $(-hb)$ represents the exponential series in $(-hb)$. (The values of $x$, $y$, and $h$ are to be expressed in $P$ units.)

Eq. 2 is valid for materials and frequencies in which the conduction current density is 100 or more times as great as the displacement (charging) current density. For copper at a frequency of 1,000 cycles per sec., the conduction current density is $10^{15}$ times the displacement current density.

If the slab is of non-magnetic material, or of ferromagnetic material at temperatures above the point at which the material becomes non-magnetic, $\mu_r$ has the value unity, and eq. 2 reduces to the following form which is equivalent to that given by J. R. Carson in "Wave Propagation in Overhead Wires With Ground Return," *Bell System Tech. Jl.*, Oct. 1926, p. 539–54.

$$C = \frac{I}{\pi} \int_0^\infty [\sqrt{b^2 + 2j} - b] \cos xb \exp (- hb - y \sqrt{b^2 + 2j})\, db \qquad (3)$$

For mounting heights for the auxiliary conductor in which $h$ is greater than 20 penetration units, eq. 3 for non-magnetic materials evaluates to the simple form

$$C = \frac{1 + j}{\pi} \frac{h}{h^2 + x^2} (\exp - y) (\cos y - j \sin y)\, I \qquad (4)$$

An examination of Table I will show that the value of the penetration unit for steel at a frequency of 960 cycles per sec. lies between 0.07 cm. for steel with an assumed relative permeability of 100 and 2.14 cm. for steel at a temperature of 1,300 deg. cent. For an auxiliary conductor mounted at a height of 1 cm. above the conducting slab, the important range of mounting heights for this steel would lie between $h = 0.5$ and $h = 20$ penetration units.

In Fig. 7 are contained curves, each worked out for a different mounting height of the auxiliary conductor, which show the manner in which the current density at the surface of the slab falls off on each side of the center line of the heated strip. All the curves have been plotted for material in the non-magnetic state save the curve marked $\mu_r = 100$, in which the relative permeability has been taken to be 100. The effect of the permeability of the steel in confining the current to a thinner surface layer of the steel and thereby causing a wider spread of the current is to be noted.

A mounting height of one penetration unit means that the height of the auxiliary conductor above the slab would be about 2 cm. for a steel slab with a strip at its welding temperature and a 960 cycle heating current. For this important case, Figs. 8 and 9 show the distribution of current densities at the surface and at points in planes located at depths of 1 and 2 penetration units below the surface. These figures also show the phase of the current density at these points, relative to the phase of the total heating current. The current density along the center line of the strip is seen to be 60 deg. in advance of the total current. At points in planes 1 and 2 penetration units beneath the surface, the current density lags substantially 1 and 2 radians behind the current density at corresponding points on the surface, and has decreased to roughly $(1/\epsilon)$th and $(1/\epsilon)^2$ of its value at the surface. In the surface at a distance of 2 penetration units from the center line of the strip, the current density is seen to be 40 per cent of the value on the center line, and thus the power expenditure per unit volume is only 16 per cent as great as along the center line.

The relative effect of close proximity of the auxiliary conductor and of a high frequency of alternation in contributing toward the concentration of the heating currents in narrow strips is brought out more clearly by plotting the current densities at the surface against the ratio of the distance $x$ of the filament to the mounting height $h$ of the auxiliary conductor, as in Fig. 10.

## Economic and Practical Features

A number of important questions of an economic and practical nature remain to be solved before the

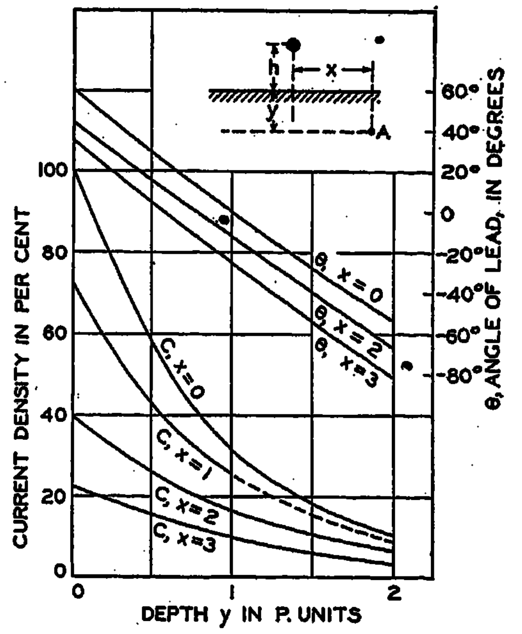

**Fig. 9. Current densities and phase angles for a mounting height of one penetration unit**

The current densities are given in per cent of the current density directly below the wire. $x$, $y$, and $h$ are in penetration units. The phase angles are the angles by which the current density leads the heating current

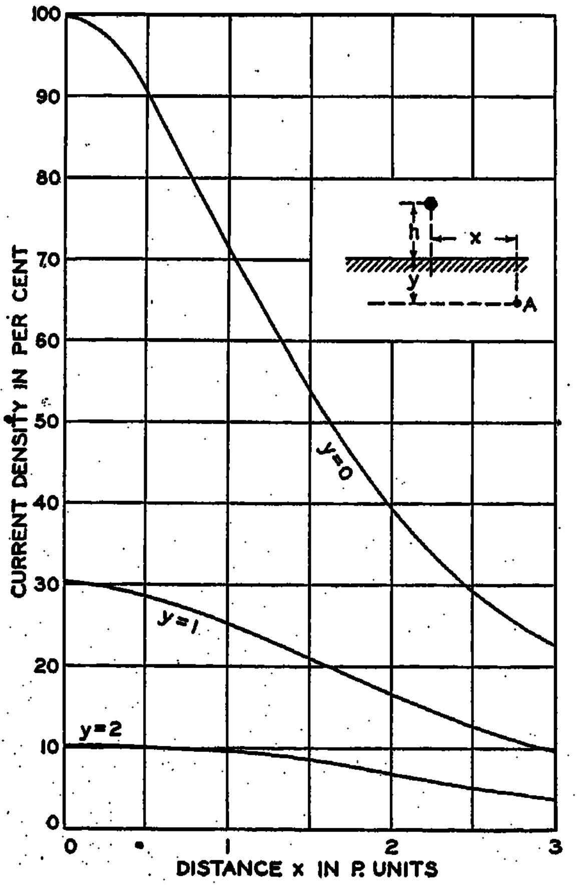

**Fig. 8. Current densities for a mounting height of one penetration unit**

The current densities are given in per cent of the current density directly below the wire. $x$, $y$, and $h$ are in penetration units

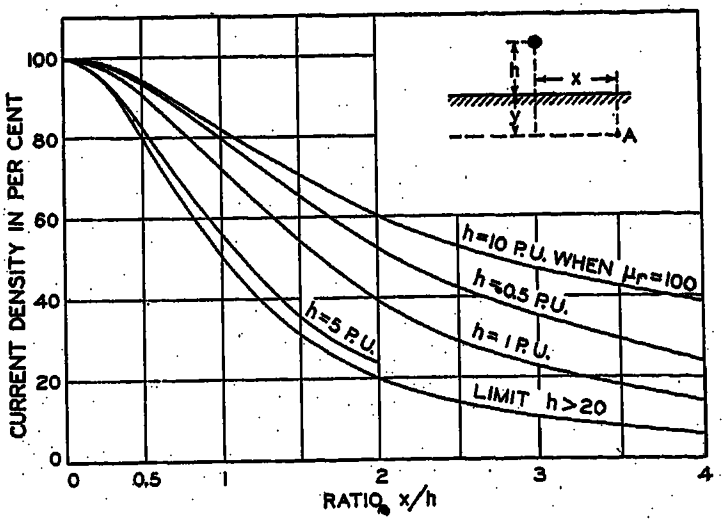

**Fig. 10. (Right) Current densities at the surface of a slab**

For each height of wire, the current densities are expressed in per cent of the current density existing immediately under the wire at that height. The distance $h$ is expressed in penetration units practise of selective heating, by means of the proximity effect, can be established as a shop process. The experiments upon which this article is based have been limited to the experience to be had with a condenser mercury-spark-gap source of high frequency currents having a rating of 35 kw.

The most economical range of frequencies for use in the process remains to be determined. Many factors which vary from operation to operation, such as the kind and size of material to be heated, the nature of the desired temperature pattern, and the relative cost of generating energy at the different frequencies will serve to determine the range of frequencies which will be the most economical. Present experience would indicate that the economic frequencies may be expected to center upon 960 cycles per sec.

Unquestionably the control of the distribution of heating currents which is made possible by the application of the proximity effect opens up a new range of industrial heating effects. It is possible to raise the temperature of a predetermined strip a few millimeters deep in a conducting plate to reach a welding temperature, while portions of the plate a few centimeters away may be substantially at room temperature. On the other hand, more gradual changes in temperature also may be secured if desired. A hitherto unattainable nicety of control of the distribution of temperatures in bodies is made available by the application of the proximity effect.

# Conductor Vibration on Transmission Lines—II

**Field tests substantiate the results of theoretical and laboratory investigations of conductor vibration on electric power transmission lines treated in an article appearing in the July issue of ELECTRICAL ENGINEERING. Among other important findings it is shown that adequate practical protection against damage from conductor vibration can be provided by the proper use of armor rods or dampers.**

By
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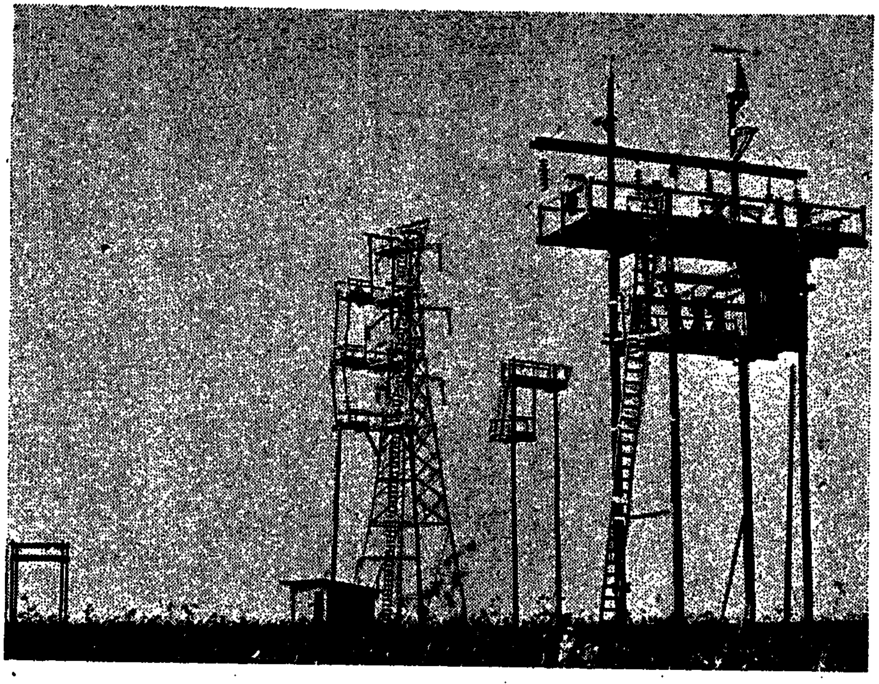

Fig. 8. Observation structures for field tests, Royse City (Tex.) experiment station

FIELD OBSERVATIONS of conductor vibration on operating power lines in various parts of the country have been coordinated with laboratory research. Early in 1930 it was decided to establish a field laboratory equipped for accurate study; accordingly a station was established near Royse City, Texas, about 35 miles east of Dallas. Chief among the considerations which led to the selection of this site were the flat unobstructed topography and the remarkably steady wind conditions. A vacant position on an existing steel tower line was made available for experimental work by the Texas Power and Light Company and additional spans were erected on wood H-frames at nearly a right angle to the existing line. This site has proved to be excellent, for hardly a day has passed without vigorous vibration being recorded on at least 1 of the 2 test lines.

In addition to the field studies at Royse City, observations have been conducted on operating lines as follows:

1. The Public Service Electric and Gas Company of New Jersey 220-kv. Roseland-Bushkill line; 795,000-cir. mil A.C.S.R. conductor and 203,000-cir. mil A.C.S.R. ground wire.
2. The Pennsylvania Power and Light Company 220-kv. Plymouth Meeting-Siegfried line; 184,000-cir. mil ground wire.
3. The Idaho Power Company 132-kv. Caldwell-Ontario line; 4/0-A.C.S.R. conductor.

Engineers of the New England Power Company have observed that under certain conditions a charged conductor tends to vibrate, presumably from the effect of corona. While allied to the general problem of conductor vibration the occurrence of vibration of this sort is probably rare. The Pacific

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Essentially full text of the last portion of a paper, "Vibration of Overhead Transmission Lines" (No. 32-90) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932.

Gas and Electric Company has made field observations of conductor vibration, and also laboratory experiments[9] on vibration dampers. Space limitations, however, prevent including more than reference to the experimental work of these and other companies.

## ARRANGEMENT OF TEST EQUIPMENT

At Royse City two test lines are available at an angle of 74 deg. thus insuring one line being favorably exposed for vibration regardless of wind direction; span lengths are 650 and 1,225 ft. on the steel towers, and 416 and 1,226 ft. on the H-frames. The ground wire on the steel towers is $^3/_8$-in. diameter 7-strand steel, while the conductors of the 132-kv. circuit on the towers are 4/0 A.C.S.R. (aluminum cable steel reinforced) equipped with armor rods. Other sizes and special types of conductors have been installed and observed for short periods. Conductor tensions are adjustable at the anchorages. General arrangement of the observation towers, which extend 12 ft. out under the conductors, may be seen in Fig. 8.

A satisfactory instrument for obtaining 24-hour vibration records was made by using an 8-inch diameter wax-coated, clock-driven chart on which the vertical motion of the conductor was recorded by a stylus attached to a pivoted arm. (See Fig. 9.) For small conductors the inertia and friction of the pivoted arm damped the vibration considerably; therefore a very light stylus attached directly to the cable was substituted. This latter arrangement, however, is satisfactory only if longitudinal motion of the conductor is restrained.

A continuous record of wind direction and velocity was obtained by an anemometer which records electrically the passage of each mile of wind on a strip chart, and a weather vane with a cam-actuated pen which records direction simultaneously on the same chart. The velocity for short periods was determined with a stop-watch and buzzer which indicates $^1/_{60}$ of a mile.

The frequency recorder consists of a uniform-speed motor-driven strip chart on which a trace of the vibration is recorded by a pencil connected to the line by a cord and spring. In addition to the foregoing, a thermograph was used to record temperature, and provision was made for observing sag and tension in the conductors.

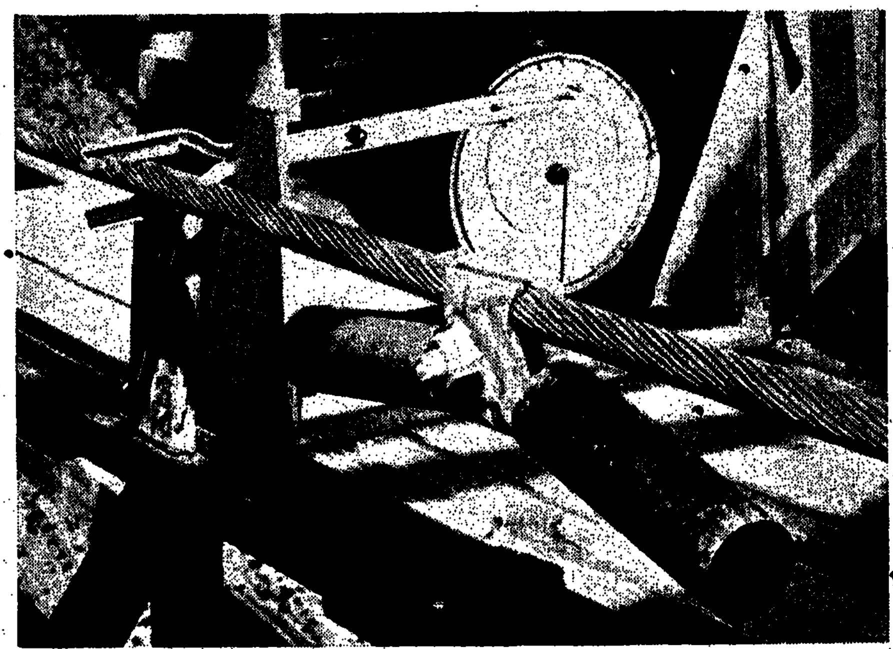


Fig. 9. Conductor vibration recorder

## THEORETICAL CHARACTERISTICS OF VIBRATION

In Fig. 10 is given a graphical solution of eq. 1 ("Conductor Vibration on Transmission Lines—I," ELECTRICAL ENGINEERING, July 1932, p. 482–7). This shows the theoretical relations between frequency, loop length, tension, and weight of a vibrating cable for common conductor sizes and tensions. A formula expressing theoretical frequency of vibration developed experimentally by Relf and Ower ("The Singing of Circular and Stream Line Wires," Aeronautical Research Committee *Report No. 825*, March 1921) is as follows:

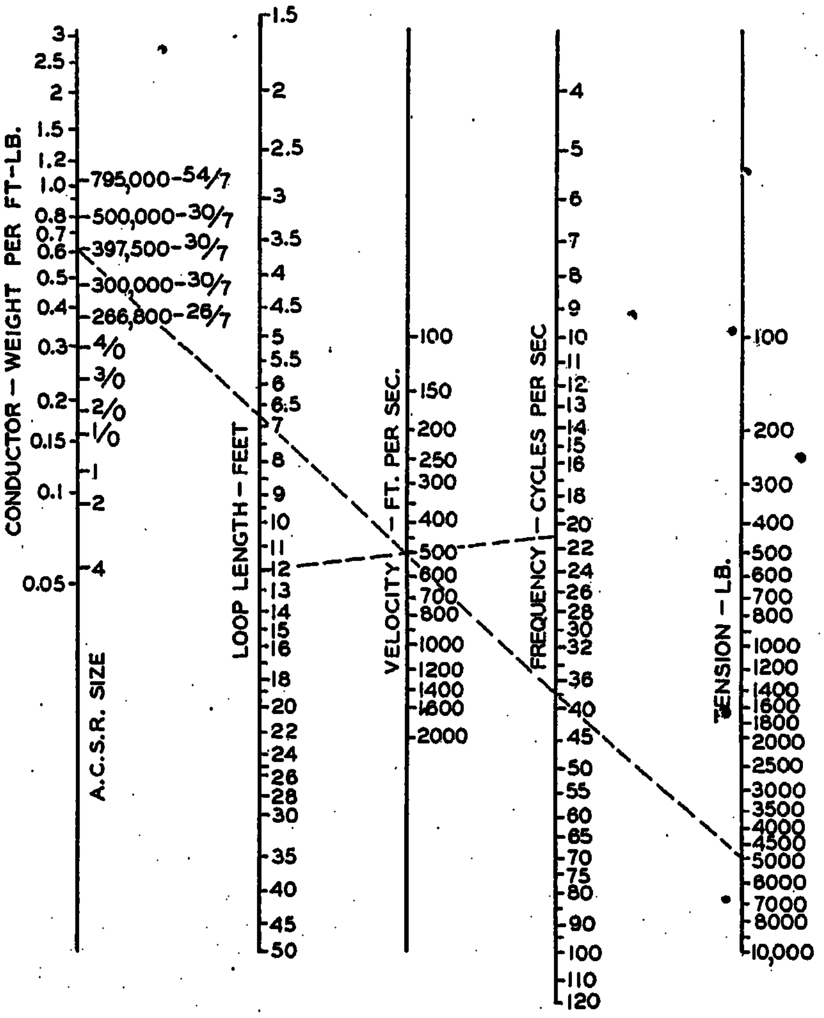


Fig. 10. Relation between weight, tension, loop length, and frequency of a vibrating cable

$$f = k\frac{V}{D} \qquad (14)$$

where

$V$ = velocity of wind in mi. per hr.
$D$ = outside diameter of the cable in in.
$k$ = a function of $(VD/e)$ where $e$ depends upon the medium, $e$ being 0.000159 for air. For ordinary sizes of conductor $k$ is a constant having a value of 3.26

A graphic solution of eq. 14 is given by Fig. 11. This formula applies to a uniform wind velocity normal to the axis of the wire. Such ideal wind conditions rarely if ever exist over a transmission span, for both velocity and direction have been found to vary widely even in short spans. ("Measurement of Wind Pressures on Overhead Lines," R. H.

## Table III—Vibration Data Pertaining to Records Shown in Fig. 12

| Record No. | Conductor: Cir. Mils or B&S Gage | Conductor: Diameter in In. | Conductor: Span Length, Ft. | Conductor: Tension in Lb | Wind: Velocity Mi. per Hr. | Wind: Angle Deg. | Observed Vibration: Loop Length, Ft. | Observed Vibration: Amplitude in 32nds In. | Observed Vibration: Frequency Cycles per Sec. | Calculated Frequency Cycles per Sec. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 795,000 | 1.093 | 1,125 | 8,216 | 8 | 37 | 24 | 34 | 12 | 11 |
| 2 | 795,000 | 1.093 | 1,125 | 8,216 | 18 | 68 | $7\frac{1}{2}$ | 18 | 43 | 35 |
| 3 | 397,500 | 0.806 | 650 | 3,822 | $5\frac{1}{2}$ | 90 | 15 | 22 | 21 | 16 |
| 4 | 397,500 | 0.806 | 650 | 3,822 | $8\frac{3}{4}$ | 90 | 7 | 5 | 34 | 33 |
| 5 | 4/0 | 0.563 | 1,226 | 2,869 | $5\frac{1}{2}$ | 70 | $7\frac{1}{2}$ | 14 | 32 | 37 |
| 6 | 4/0 | 0.563 | 1,226 | 2,869 | 10 | 70 | 6 | 4 | 51 | 47 |
| 7 | No. 2 | 0.316 | 650 | 676 | 5 | 60 | $3\frac{5}{8}$ | 2 | 60 | 61 |
| 8 | No. 2 | 0.316 | 650 | 676 | 8 | 60 | $2\frac{2}{3}$ | 2 | 75 | 85 |

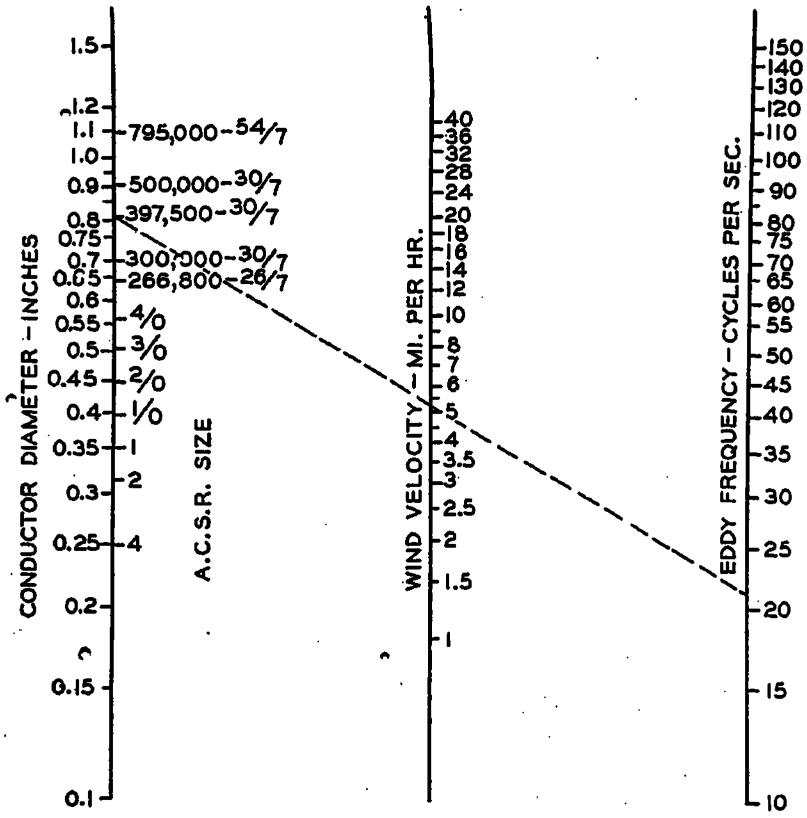


Fig. 11. Graphical solution of Relf and Ower formula for wind eddy frequency of circular cables

Sherlock, N.E.L.A. *Bulletin,* Jan. 1931, p. 29.) ("Characteristics of Wind Gusts," R. H. Sherlock and M. B. Stout, N.E.L.A. *Bulletin,* Jan. 1932, p. 20.) Velocity varies with elevation, and in a long span the height of conductor is not constant; direction shifts rapidly as indicated by any weather vane. The normal component of velocity probably should be used in computing frequency when direction of the wind is oblique. This assumption seems to be in error for small acute angles. A cable has considerable inertia and when once vibrating in any particular mode will not change frequency quickly with slight changes in wind direction or velocity. For these reasons the observed frequency sometimes differs greatly from the theoretical, but with steady wind and obliquity not under 45 deg. the agreement usually is close.

### Field Records of Vibration

Numerous records of frequency and amplitude for conductors of various sizes have been obtained. Fig. 12 shows characteristic vibration records for each of four sizes of A.C.S.R. with pertinent data given in Table III. Agreement between observed and calculated frequencies is fairly close. These records all show recurring beats, possibly caused by variations of wind velocity; with span length and frequency known, the time between recurrences of any particular beat determines velocity of wave propagation, tension, and theoretical loop length.

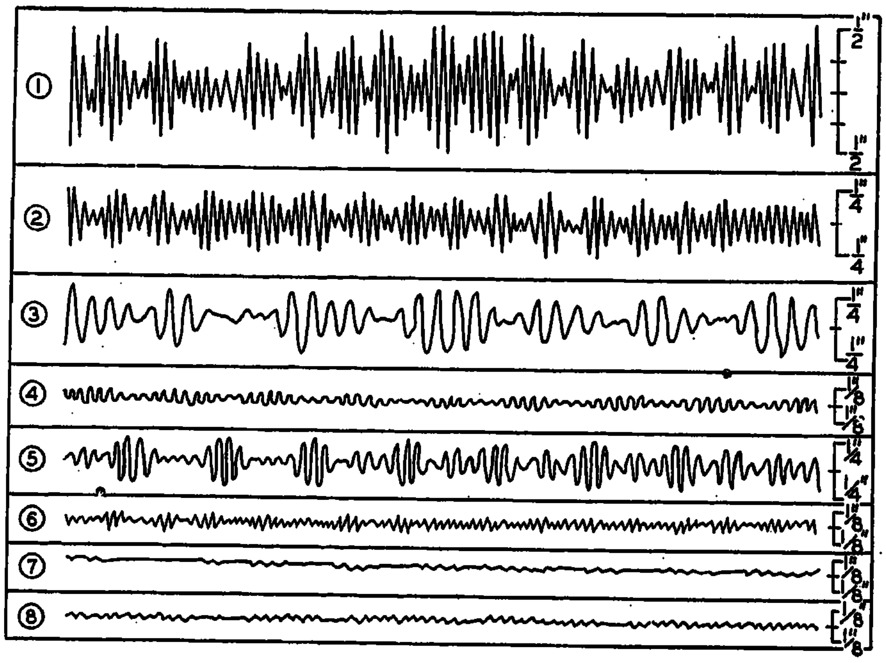


Fig. 12. Vibration records for four sizes of A.C.S.R., see Table III

Observation proves the statement that cables of any material will vibrate when conditions are favorable. One of the earliest instances of damage from vibration was recorded over 20 years ago on the Carquinez Straights Crossing of the Pacific Gas and Electric Company. A few years after installation breakage of strands was discovered in the heavy plough-steel conductors. It is interesting to note that the use of parallel reinforcing or stiffening cables extending some distance out from the support, which was developed here, have been used since on many long river crossing spans.

Records of frequency and amplitude of vibration for conductors made of materials other than A.C.S.R. are shown in Fig. 13; data pertaining to these records are given in Table IV.

### Influence of Tension

Vibration frequency is a function of wind velocity and diameter of conductor and is independent of tension. From eq. 1 it may be seen that for a given frequency the loop length, however, varies directly as the square root of the tension. Therefore, an increase in tension increases loop length and theoretically should render it more difficult for the conductor to fall into resonance with the wind eddy frequency.

Field records to determine the effect of tension were obtained at Royse City; 2 No. 2 A.C.S.R. conductors were erected on a 416-ft. span with tensions of 500 and 750 lb., respectively. Simultaneous 24-hr. records were taken for several weeks, a typical record being shown in Fig. 14; as may be seen, both conductors vibrated for about the same period of time and the amplitude increased slightly with an increase in tension.

Another tension test was made on a 1,160-ft. span of 795,000 cir. mil A.C.S.R. in New Jersey. The tension was 5,400 lb. in one of the parallel conductors and 9,000 lb. in the other, a difference of over 50 per cent. Comparative records were obtained for several weeks during which vibration occurred on a few occasions, but for short periods only. The results were comparable to those obtained at Royse City.

From these tests it appears that vibration will occur at any practical tension when wind conditions are favorable. A reduction of tension decreases the direct stress in the conductor but does not decrease the tendency to vibrate.

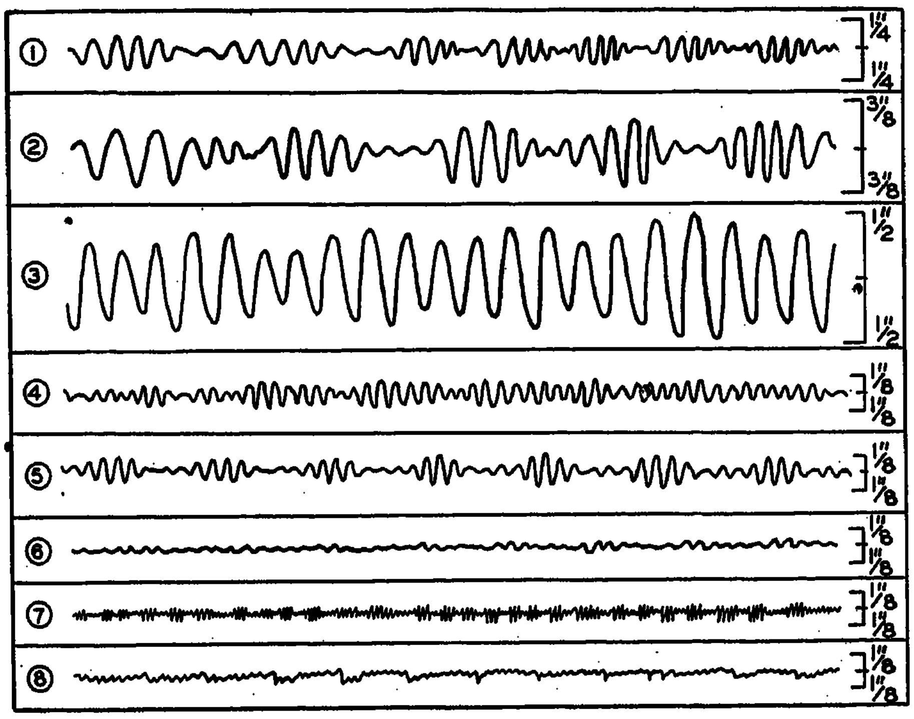


Fig. 13. Vibration records for cables of various materials; see Table IV

## Influence of Conductor Shape

It is obvious that the shape of a conductor should influence its vibration, and field tests prove that it actually does. At Royse City the relatively smooth No. 2 and 397,500 cir. mil A.C.S.R. are observed to vibrate more frequently than the 4/0 which has a comparatively rough exterior due to larger strands.

A special test to show influence of shape was made with three No. 2 all aluminum conductors, 1 a single wire, 1 of 3 strands, and 1 of 7 strands. Over a

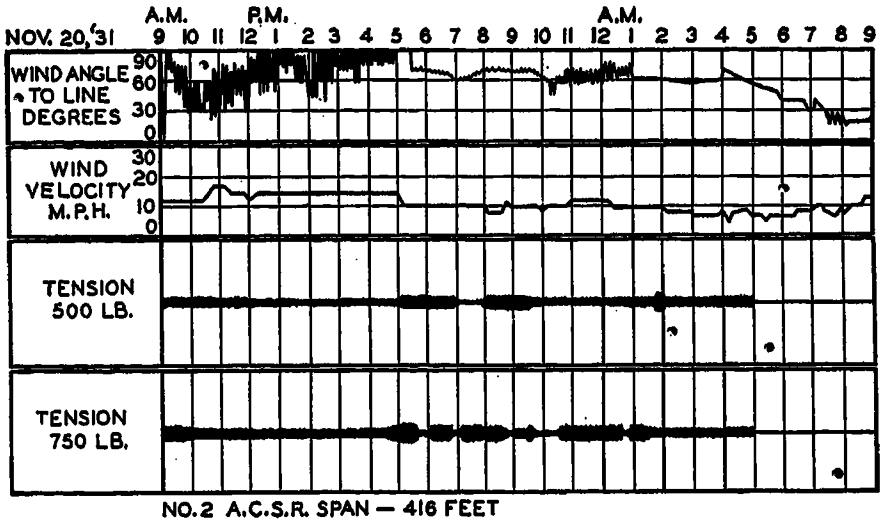


Fig. 14. Vibration records showing effect of tension

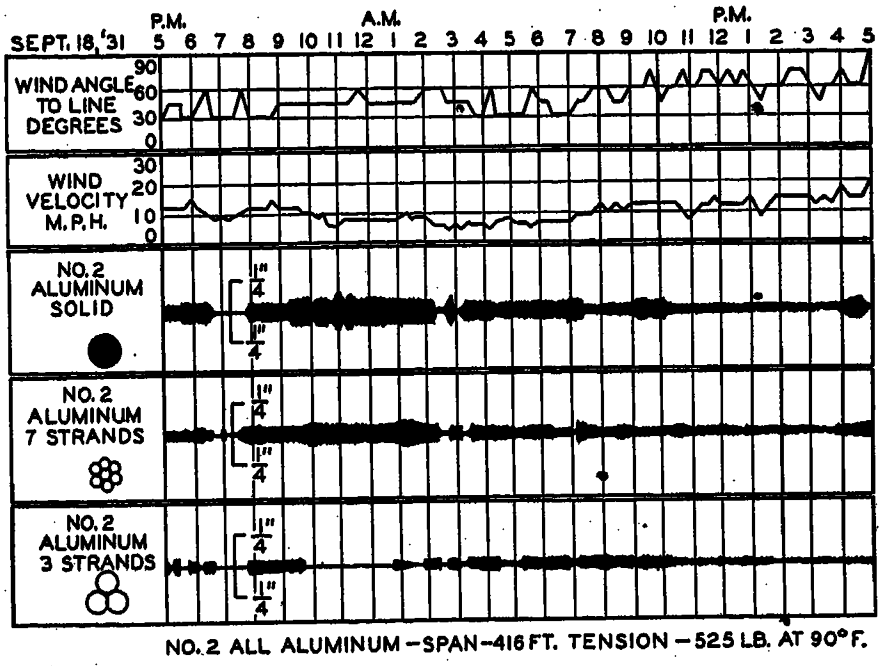


Fig. 15. Vibration records showing effect of conductor stranding

Table IV—Vibration Data Pertaining to Records Shown in Fig. 13

| | Conductor | | | | Wind | | Observed Vibration | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Record No. | Size and Material | Diameter in In. | Span Length, Ft. | Tension in Lb. | Velocity Mi. per Hr. | Angle Deg. | Loop Length, Ft. | Amplitude in 32nds In. | Frequency Cycles per Sec. | Calculated Frequency Cycles per Sec. |
| 1 | 650,000 cir. mils copper calson bronze core | 1.13 | 835 | 9,500 | 4.5 | 90 | 11.5 | 12 | 16 | 14 |
| 2 | | 1.13 | 835 | 9,500 | 2 | 85 | 17.7 | 19 | 10 | 9 |
| 3 | 400,000 cir. mils 19 str. copper | 0.728 | 1,200 | 5,100 | 4 | 70 | | 32 | 21 | 18 |
| 4 | 250,000 cir. mils 19 str. copper | 0.575 | 1,125 | 5,550 | 5.75 | 66 | 8 | 9 | 29 | 30 |
| 5 | 250,000 cir. mils 19 str. copper | 0.575 | 1,125 | 5,550 | 6 | 66 | 8 | 9 | 25 | 31 |
| 6 | 4/0 copper | 0.528 | 750 | 3,200 | 6.8 | 80 | 6.9 | 6 | 25 | 29 |
| 7 | 3/8 in. steel | 0.375 | 650 | 3,800 | 8.75 | 90 | 3.75 | 4 | 88 | 89 |
| 8 | 3/8 in. steel | 0.375 | 650 | 3,800 | 10 | 75 | 3 | 3 | 99 | 102 |

period of several weeks 24-hr. vibration charts were obtained for several tensions. The recorders being set the same distance from the supports, and the tensions being the same, the amplitudes are comparable. Typical charts are shown in Fig. 15; these indicate that the 3-strand cable vibrated least frequently and with the smallest amplitude, the 7-strand was second, and the solid wire vibrated the most. In no case was vibration absent.

Another test was conducted on a special eccentric A.C.S.R. (418,000 cir. mils of aluminum); the outer layer of strands in this cable, being graduated in size, formed an enlargement which wound helically around the conductor axis. This cable was installed on a span of 1,125 ft. parallel to a standard 397,500 cir. mil A.C.S.R. of approximately the same diameter and proportion of steel. A record showing comparative vibration of the 2 cables is shown in Fig. 16.

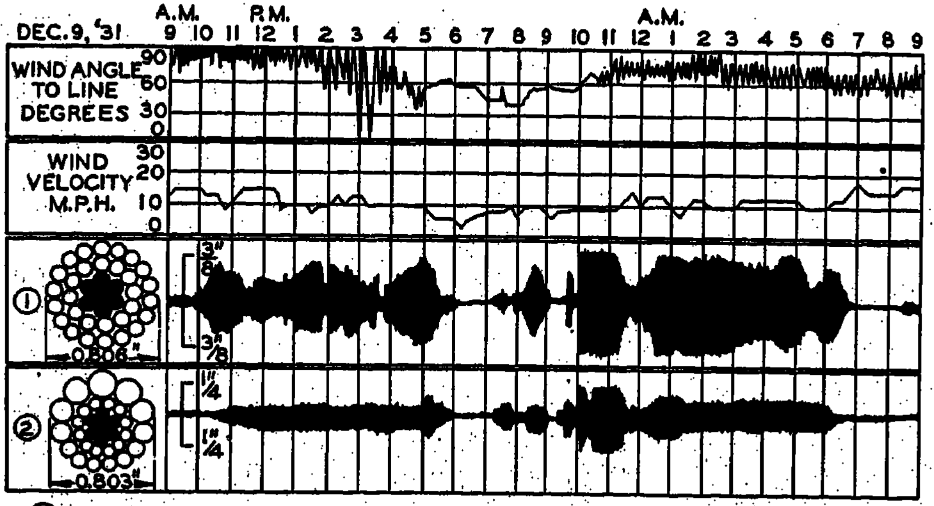
These experiments show that amplitude can be reduced by variation in shape but that it is doubtful if a practical vibrationless conductor can be obtained in this manner.

## Energy Transmitted to Supports

Severe conductor vibration sometimes causes supporting structural members to vibrate noticeably, and fatigue failures at bolt holes in small alloy steel crossarm members have been reported. To measure the variation in vertical load transmitted to the structure a small steel rod of high elastic limit was inserted between the suspension clamp and the insulator string on a 1,125-foot span of 795,000 cir. mil A.C.S.R. An accurate load-deformation curve for this rod had previously been determined with a Huggenberger tensometer. Several readings made under varying conditions of vibration showed that the variation in vertical load was of the order of 100 to 150 lb.

**Table V—Vibration Data Pertaining to Records of Fig. 17**

|  | A.C.S.R. Conductors |  |  |  | Recorder |
|---|---|---|---|---|---|
| Record No. | Size in Cir. Mils or B & S Gage | Diameter in In. | Span Length, Ft. | Tension in Lb. @ 60° F. | Distance from Support |
| 1 | 795,000 | 1.093 | 1,125 | 6,755 | 5 ft. 2 in. |
| 2 | 795,000 | 1.093 | 1,125 | 6,810 | 5 ft. 0 in. |
| 3 | 397,500 | 0.806 | 1,125 | 4,200 | 4 ft. 5 in. |
| 4 | 397,500 | 0.806 | 1,125 | 4,085 | 2 ft. 9 in |
| 5 | 4/0 | 0.563 | 416 | 2,025 | 2 ft. 9 in. |
| 6 | 4/0 | 0.563 | 416 | 2,000 | 4 ft. 0 in. |
| 7 | No. 2 | 0.316 | 416 | 740 | 3 ft. 1 in. |
| 8 | No. 2 | 0.316 | 416 | 720 | 3 ft. 1 in. |



① 397,500 CIR. MILS A.C.S.R. SPAN – 1125 FT. TENSION – 4516 LB. AT 60° F.
② 418,000 CIR. MILS ECCENTRIC CABLE – SPAN – 1125 FT. TENSION – 4460 LB. AT 60° F

**Fig. 16. Vibration records showing effect of eccentric conductor cross-section**

## Moving Pictures of Vibrating Cable

An ordinary moving picture camera taking 16 exposures per second is too slow to show vibration at a frequency of 25 cycles or more; a high-speed camera, however, taking 128 exposures per second "slows down" the vibration so that the motion of the cable can be followed readily on the screen. One reel was taken of a 795,000-cir. mil A.C.S.R. while the wind velocity was high and the cable vibrating with short loop length, high frequency, and small amplitude. A second reel was taken while the wind velocity was low with correspondingly lower frequency, longer loop length, and greater amplitude. Rocking of the suspension clamp is clearly shown and beat pulsations are evident.

## Effect of Dampers

The problem of damping a vibrating conductor differs from many damping problems in that the damper must be effective over a wide range of frequencies. This precludes the use of a tuned dynamic vibration absorber for which the theory was presented by J. Ormondroyd and J. P. DenHartog ("The Dynamic Vibration Absorber," *Trans.*

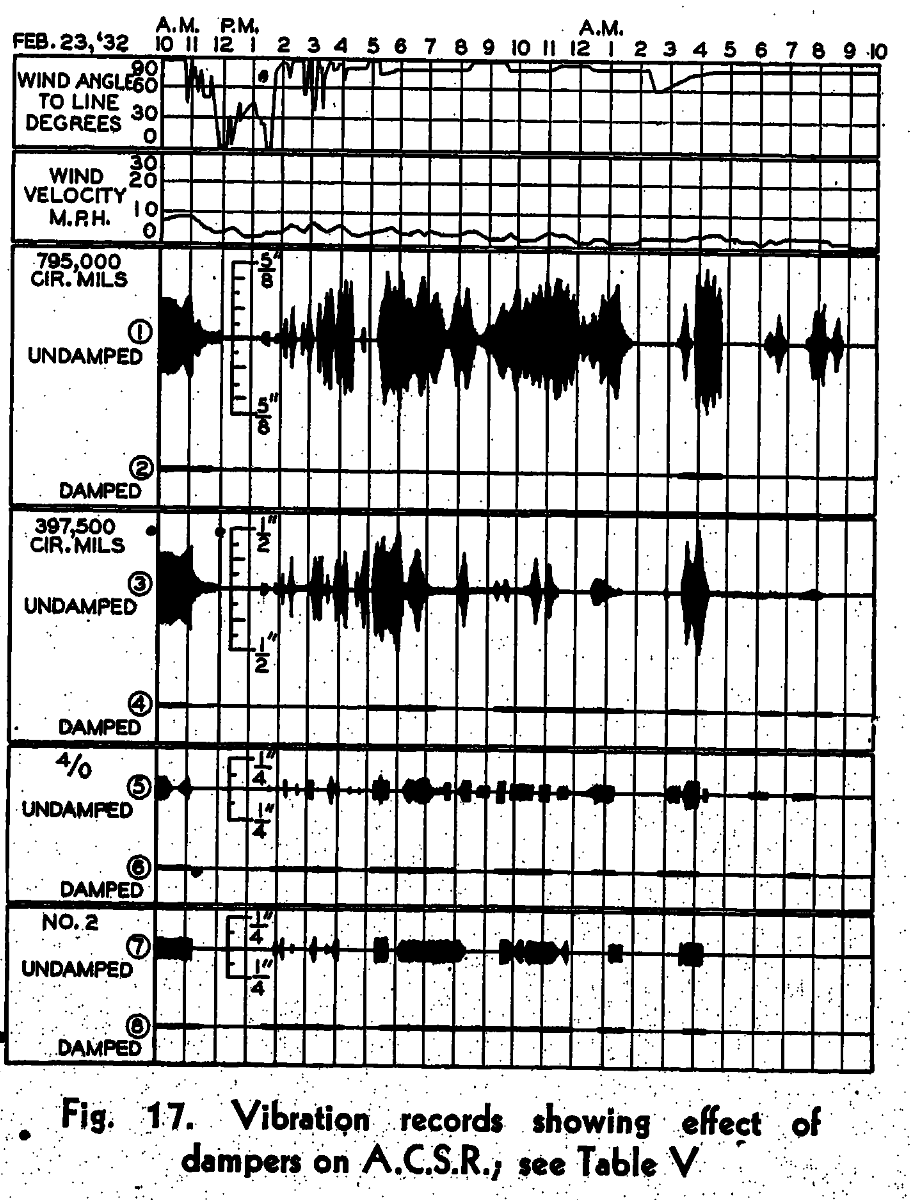


**Fig. 17. Vibration records showing effect of dampers on A.C.S.R., see Table V**

## Table VI—Vibration Data Pertaining to Records Shown in Fig. 18

| | Conductor | | | | Wind | | Observed Vibration | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Record No. | Size and Material | Diameter in In. | Span Length, Ft. | Tension in Lb. | Velocity Mi. per Hr. | Angle Deg. | Loop Length, Ft. | Amplitude in 32nds In. | Frequency Cycles per Sec. | Calculated Frequency Cycles per Sec. |
| 1 | 4/0 A.C.S.R. | 0.563 | 550 | 2,630 | 3 | 75 | 11.95 | 6 | 23 | 22 |
| 2 | 4/0 A.C.S.R. | 0.563 | 550 | 2,630 | 3 | 75 | | | | |
| 3 | 4/0 A.C.S.R. | 0.563 | 550 | 2,650 | 4 | 75 | 11.7 | 8 | 23 | 22 |
| 4 | 4/0 A.C.S.R. | 0.563 | 550 | 2,650 | 4 | 75 | | | | |

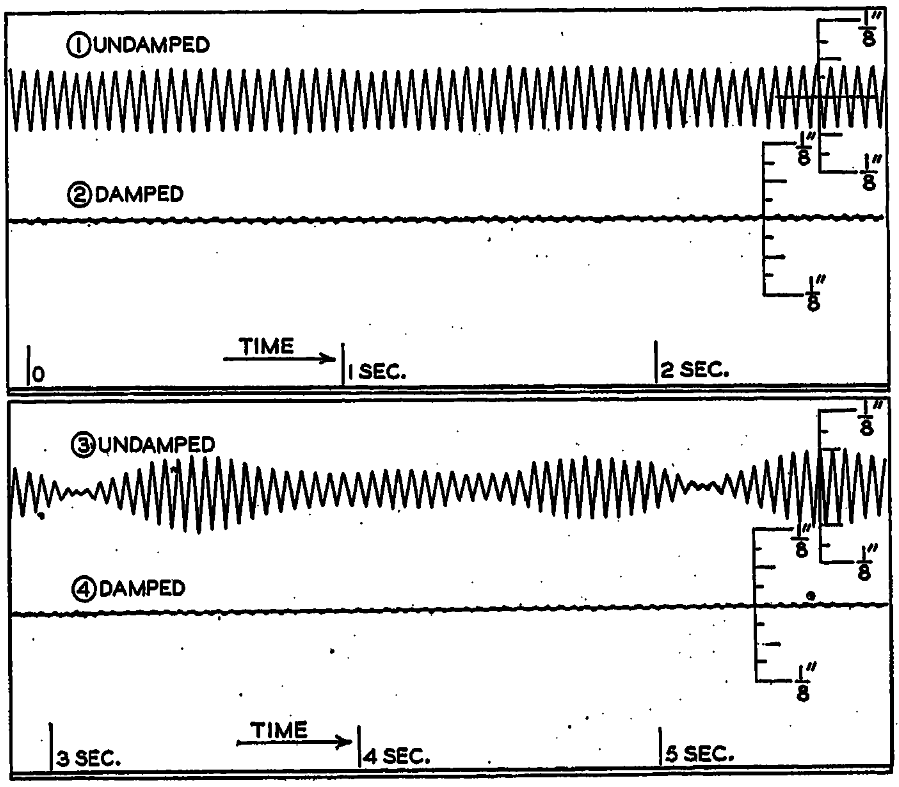


Fig. 18. Oscillographic vibration records showing effect of dampers on 4/0 A.C.S.R., Caldwell-Ontario (Idaho Power Company) 132-kv. line; see Table VI

A.S.M.E., 1928). Such an absorber theoretically consumes no energy; hence it seems that it cannot damp vibration where there is a continuing input of energy as on a transmission line. The dynamic absorber with damping is effective over a broad band of frequencies and also consumes energy. The theoretical formulas of the Ormondroyd-DenHartog paper for this type of damper are applicable to a vibrating cable in principle only and require extensive modification and laboratory determination of certain constants.

It is of interest to note that a simple weight of suitable size at the center of one loop of a vibrating cable is somewhat effective as a damper. The added weight alters the natural period of that one loop and, with the forced vibration which then ensues in that particular loop, the vibration is damped by consumption of energy in the conductor itself in that loop. The practical difficulty is, however, that a node is soon established at the weight and vibration is renewed.

Energy which must be consumed to damp vibration is undoubtedly extremely small in amount. This is evident from the theoretical formula developed by Bate ("The Vibration of Transmission Conductors," *Trans.* Inst. Engrs., Australia, 1930, p. 277) for the input of energy to a cable from wind eddies. His formula involves several assumptions which have not been proved but the method of derivation is logical and dimensionally it is probably correct. The formula gives the energy input per loop per cycle, $G$ in ft.-lb., as follows:

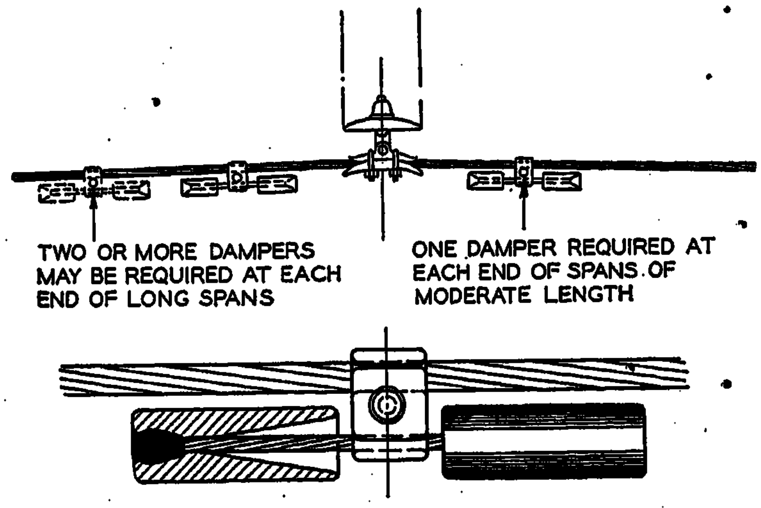

TWO OR MORE DAMPERS MAY BE REQUIRED AT EACH END OF LONG SPANS
ONE DAMPER REQUIRED AT EACH END OF SPANS OF MODERATE LENGTH

Fig. 19. Stockbridge damper assembly

$$G = 0.000022\ V^2DAL' \qquad (15)$$

where

$V$ = velocity of wind in mi. per hr.
$D$ = outside diameter of the cable in in.
$A$ = amplitude of vibration in in.
$L'$ = loop length or distance between node points in ft.

This formula shows that the input of energy is proportional to the amplitude; hence if amplitude can be restrained to a small value the energy input will be small. This agrees with the observed fact that vibration builds up slowly and is damped easily at first.

One reason for establishing the outdoor laboratory was to study the action of dampers. The usual method of observation is by comparison of 24-hr. vibration records from 2 conductors identical in size, span length, and tension, 1 damped and 1 undamped. Many different dampers have been tested at Royse City, and hundreds of comparative records have been obtained.

The most successful damper tested is essentially a mass resiliently attached to the conductor in the loop nearest the support and so designed that energy is consumed by friction or mechanical hysteresis. This damper was developed by G. H. Stockbridge of the Southern California Edison Company. The usual form consists of 2 weights connected by a short piece of stranded steel cable, this assembly being attached to the conductor a short distance out from the insulator. This damper is simple and practical to construct and easy to install, even on hot lines. The weight, size, and length of stranded cable, and location in the span vary for different diameters of conductor. For spans of moderate length, say under 1,000 ft., 1 damper at each end of the span is required.

Comparative 24-hr. vibration records are shown in Fig. 17 with supplementary data in Table V, for a damped and an undamped span of 4 sizes of A.C.S.R. at Royse City, including wind direction and velocity recorded at one end of the span. It is evident that the dampers suppressed practically all visible vibration; also that the energy input from the wind is directly proportional to the length of the span. In long spans better damping is obtained with 2 dampers at each end, while 3 or more may be required on extremely long spans.

A damper cannot act effectively until the conductor vibration acquires a certain amplitude. This is manifested by a slight quiver which can be felt but barely seen. The 24-hr. charts, however, do not show this clearly. Recently a series of records from a free and a damped span of 4/0 A.C.S.R. was obtained by engineers of the Idaho Power Company using a carbon pile oscillograph; Fig. 18 shows 2 of their oscillograph records. The ripple in the damped cable is scarcely visible even at the enlarged scale.

Many tests on Stockbridge dampers have been made to determine the best dimensions and point of attachment to the conductor. The dampers are not critical either as regards size or spacing—a variation of 25 per cent in any factor will not seriously affect performance. Fig. 19 shows the style of Stockbridge damper used in this investigation. To avoid corona discharge this design embodies cylindrical weights which shield the damper cable, and a clamp having no sharp corners.

## ARMOR RODS

Armor rods are primarily reinforcement but they also are effective as dampers. Numerous comparative records have indicated that they reduce vibration amplitude by 10 to 20 per cent. Armor rods reduce stresses by distributing the bending from vibration, reinforce the cable at the point where the stresses are greatest, and furnish valuable protection against flashover burns.

## CONCLUSIONS

Principal findings of the field tests described in this article may be summarized as follows:

1. Theoretical formulas (*loc. cit.*) expressing relationship between frequency, loop length, tension, and weight of a vibrating conductor are in good agreement with field observations.
2. The Relf and Ower formula (*loc. cit.*) for the frequency of a vibrating cable is substantially correct.
3. Any suspended cable will vibrate when conditions are favorable.
4. Any feasible reduction in tension will not prevent vibration.
5. Modifications in shape of cable cross section and stranding have some beneficial effect in reducing amplitude, but the results do not support the idea that a vibrationless cable can be evolved.
6. Variation in vertical load transmitted to the insulator is not large.
7. Slow-motion moving pictures of vibrating cable enable the motion to be followed by eye but have been of little assistance.
8. A properly designed damper will prevent vibration of any appreciable amplitude, and since the input of energy from the wind varies directly as the amplitude an effective damper is required to absorb but little energy.
9. The Stockbridge damper gives best results, is simple in design and construction, has no moving parts, and is easy to install.
10. Armor rods are primarily reinforcement although they reduce the amplitude of vibration by 10 to 20 per cent.
11. Adequate practical protection against damage from vibration of conductors is afforded by proper use of armor rods or dampers.

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# Engineering Subjects in the College Program

**For each of a large number of technical institutions, the various electrical and related subjects in the 4-year college program of electrical engineering have been subjected to an analysis. The results of this study are presented herewith, with suggestions for improvement in existing curricula.**

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IN THE FIELD of education for electrical engineering both the teacher and the practising engineer are vitally concerned; the teacher, because it is his life work, the practitioner because the young graduates are presumably trained to meet the specifications of his profession, to join its ranks, and to work beside him in the years to come. Obviously the working relations of man to man and the characteristics of the profession will be determined more or less by the nature of the training given the young men who come into it at the rate of approximately 3,000 a year. In this sphere 2 great national organizations, the Society for the Promotion of Engineering Education and the American Institute of Electrical Engineers, have mutual interests and interlocking membership. It would seem well to set aside for the special consideration of the S.P.E.E., the methods of selection, the study of teaching methods, the operating details, and organization of curricula; but certainly then, it is the special function of the A.I.E.E. to advise as to the economic and professional content and interrelations of programs.

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Full text of "Engineering Subjects, Electrical and Cognate, in the Four-Year College Program of Electrical Engineering" (No. 32-74) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932.

As a matter of background, the study of engineering education by the S.P.E.E., 1923–1929, brought out a synthesis of opinion from teachers and engineers as to what engineering curricula should be. This, presented in "Report of the Investigation of Engineering Education," v. 1, p. 413, is as follows:

1. Moderate diversity but tending away from specialization.
2. Dominance of the scientific and broadly technical content and emphasis.
3. Inclusion of a well-identified core of required subject matter.
4. Inclusion, at all stages, of subjects of purely cultural value.
5. Due emphasis (though not predominant) on the economic aspects of engineering and on their bearing on administration and management.
6. Coherence of arrangement and coordination of related subjects.
7. Thoroughness rather than completeness of detail.

It will be remembered with regard to "specialization" that instead of the general sense of the word as applied to the differentiation of instruction in accordance with the major divisions of engineering—civil, electrical, mechanical, etc., the S.P.E.E. used the term in the above discussion in a narrower sense as applied to a further degree of differentiation of curricula within the major fields themselves, such, for example, as the provision of distinct curricula in sanitary engineering, structural engineering, and the like, within the major field of civil engineering. There was common agreement between the teachers and engineers that the primary purpose of instruction in specialized engineering subjects should be to teach fundamental principles and methods rather than to train for particular kinds of work. The engineers emphasized the opinion that specialization is out of place in undergraduate curricula and that thorough grounding in fundamentals is of paramount importance. Yet many of the teachers believed that in teaching specialized engineering subjects there is no essential conflict between preparation for particular fields of work and training in fundamental principles and methods, although the latter should always be the primary purpose. It has been a standard educational policy that principles are best taught in connection with their applications, and that the technical subjects proper should serve as media for teaching principles and the characteristic engineering methods of thought and analysis, instead of attempting preparation for specific types of practise.

**Table I—Semester Hours Average Requirements for Graduation in Electrical Engineering**

| S.P.E.E. Report, 1923–1929 Subject Group | Units | S.P.E.E. Report, 1930 Subjects | Units |
|---|---|---|---|
| Electrical Engineering | 34.4 | Technological Subjects<br>Major Branch | 39.0 |
| Other Engineering | 42.1 | Other Technical Subjects | 23.5 |
| Engineering Electives | 6.8 | Electives | 10.4 |
| Non-Engineering Electives | 1.8 | Shop | 4.6 |
| Miscellaneous | 0.1 | Drawing | 7.2 |
| Phys. and Mil. Training | 6.6 | Phys. and Mil. Education | 4.6 |
| Foreign Language | 2.1 | Modern Foreign Language | 1.2 |
| Social Science | 4.4 | Economics | 4.7 |
| Physical Science | 20.6 | Physical Science | 20.7 |
| English | 8.9 | English | 9.0 |
| Mathematics | 18.9 | Mathematics | 18.5 |
| Total Non-Engineering | 63.6 | | |
| Total Engineering | 83.3 | | |
| Total Prescribed | 137.6 | Total Prescribed | 133.0 |
| Total Elective | 9.3 | Total Elective | 10.4 |
| Grand Total | 146.9 | Grand Total | 143.4 |
| Number of Institutions | 55 | Number of Institutions | 51 |

The engineers were strongly in favor of extended training in economics and for a greater emphasis upon the economic phases in the engineering subjects proper. A large majority of the teachers, engineers, and graduates who were questioned indicated the belief that foreign languages as taught at that time were not of sufficient value to warrant their inclusion as requirements in the engineering curriculum. Both teachers and engineers were in agreement that shop work should not be required of all students, but only of those enrolled in curricula most closely related to the manufacturing industries. As a result of these definite criticisms and recommendations, chiefly with regard to the preparatory and secondary courses in the curricula, many of the colleges have changed their requirements to meet the recommendations. The progress in this respect may be estimated by comparing the 2 columns in Table I. Unfortunately, the 2 tabulations were not made in exactly the same subdivisions, but "Shop and Drawing" listed as items in the 1930 report are evidently included in the "Other Engineering" item of the 1923–1929 report, while "Engineering Electives," "Non-Engineering Electives" and "Miscellaneous" of the 1923–1929 report are doubtless all combined into the item of "Electives" in the 1930 report. The other subjects, however, listed side by side, appear to agree exactly.

The slight increase in English and economics with the corresponding decrease in modern foreign languages is notable. Still this does not show the full effect of the change, since some colleges still are revising their curricula in this respect. For example, the college of engineering at the University of Michigan will change its requirements as of September 1932, dropping 16 hours of foreign language or non-technical electives in favor of 4 additional hours required in English, 6 hours required in economics, and 6 hours of free non-technical electives.

It is believed, then, that a great improvement has been made in the preparatory and secondary parts of the curriculum in electrical engineering as a result of the foregoing study and discussion. Some glaring omissions have been remedied and some old ideas have given way to new and present conditions. The fact that the recommendations after careful analysis by the colleges have been so widely adopted shows how valuable the recommendations of the practising engineers have been, and how much they have achieved. We should expect, therefore, similar advantages to accrue from a study and discussion of the technical portion of our curriculum in something like the detail which was thus given to the preparatory and secondary subjects.

## TECHNOLOGICAL SUBJECTS

With regard to the technological portion of the curriculum in electrical engineering the tabulations of the total semester hours allotted to these subjects in the major branch of electrical engineering itself, those in other engineering fields and those in engineering electives, in the 1923–1929 and 1930 S.P.E.E. reports, are given in Table II.

It is noted that while there has been an increase in the central core of subjects in electrical engineering itself from 34.4 to 39.0, still the electrical curriculum contains fewer technical courses in its own field than any of the other major curricula, particularly those of chemical and civil engineering with their respective requirements of 44.9 and 50 semester hours in their own major branch. It would appear, then, that the electrical engineering students take proportionately more of their technical work in associated departments and in electives, a situation which will heartily commend itself from the points of view of broad foundational training and freedom for the student to pursue his ambitions to at least a slight degree into some particular field of his own choice.

The tendency to increase the number of semester hours of technical requirements in electrical engineering was noted in the 1923–1929 S.P.E.E. report. That it prevailed and resulted in an 11 per cent increase is shown by the report for 1930. In view of the close approach to an upper limit, should we not examine how scientific the training of a 4-year electrical student should be? Doubtless we are all agreed that he must have as an absolute minimum, say, some 16 semester hours of fundamentals in d-c. and a-c. machinery and steady-state circuits. But in the light of modern developments and in preparation for some known problems of the future, how much further should we go?

The electrical engineers who were consulted in 1923–1929 as to which divisions of electrical engineering were of such importance as to warrant their inclusion in the training of all electrical students replied as shown in Table III. (It was taken for granted that a general foundation in the principles of electrical and magnetic units, laws, circuits, and machines would be required of course in every case.) In view of the developments of the past few years and of immediate future demands, surely the subject of electronics and vacuum tubes should be added to the list. Such a course should include an engineering approach to the theories of ionization, of the mechanisms of current flow and energy interchanges in ionized regions, and of thermionic, photoelectric, and other types of electron emission, as related to conducting gases at atmospheric and lower pressures. The study should cover thermionic vacuum tube characteristics and types of circuits and tubes suitable for rectifiers, amplifiers, detectors, and oscillators.

**Table II—Semester Hours Required for Graduation in Different Courses**

| 1923–1929 | | 1930 | | | | |
|---|---|---|---|---|---|---|
| Subjects | Units | Subjects | E.E. | M.E. | C.E. | Ch.E. |
| Elec. Engg. | 34.4 | Technological Major Branch | 39.0 | 41.0 | 50.0 | 44.9 |
| Other Engg. | 42.1 | Other Technical Subjects | 23.5 | 22.9 | 18.4 | 21.6 |
| Engg. Electives | 6.8 | Electives | 10.4 | 9.3 | 8.4 | 6.7 |
| Grand Total | 146.9 | Grand Total | 143.4 | 145.5 | 144.0 | 146.4 |
| No. of Institutions | 55 | No. of Institutions | 51 | 44 | 51 | 41 |

ANALYSIS OF COLLEGE CURRICULA

Not all of the subjects in Table III are standard requirements in college curricula but nearly all are represented in the programs as requirements or available electives, the exception being perhaps electrochemical engineering which in practically every case is offered in the departments of chemistry. The study summarized in Table IV shows what a number of representative schools provide in required and elective courses in these subjects.

It is notable that there is great consistency in the first 4 columns of Table IV in that nearly all colleges require a group of fundamental courses of not less than 16 hours and also provide 1 or 2 courses in transmission and distribution, power plants, and electrical machine design. The few schools whose catalogs do not show a course in electrical power plants provide a strong preparation in the courses they schedule in the heat power division of mechanical engineering. There is also strong agreement in using the field of power plant engineering as the vehicle for applying economics to engineering problems. In the remaining columns for the electrical division of Table IV the courses offered are mainly elective, the restriction of time allowing the undergraduate student probably not more than 1, or at most 2, courses in any division. Many colleges offer several sequential electives in the various divisions, but the courses are principally for graduate students. There are difficulties in analyzing the curricula in these divisions. Illumination may be offered in some cases in the department of physics; telephony, telegraphy, radio, and electronics, may be combined in various ways in courses given as communication engineering.

**Table III—Per Cent of Engineers Favoring Inclusion of Various Subjects**

| Per Cent | Subjects | Per Cent | Subjects |
|---|---|---|---|
| 67.5 | Transmission and distribution | 33.5 | Illumination |
| 59.0 | Power plant engineering | 33.2 | Electrochemical engineering |
| 57.0 | Electric machine design | 28.4 | Electric railways |
| 44.0 | Industrial power engineering | 22.5 | Telephony-telegraphy |
| 38.8 | Hydroelectric engineering | 19.5 | Radio engineering |

RELATED ENGINEERING SUBJECTS

In order that the preparation shall have a proper breadth, and that the graduate shall understand something of the problems facing his colleagues, what should be the training of electrical students in the fields of the associated technical departments of mechanical, chemical, and civil engineering?

In mechanical engineering the electrical student has need of a fundamental course dealing in elementary thermodynamics, steam, fuels, boilers, steam

## Table IV—Required Semester Hours for Students of Electrical Engineering—1931

| | Electrical Divisions | | | | | | | | | | | Mechanical | | | Civil | | | | Chemical |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name of Institution | Fundamental Courses | Trans. and Dist. | Power Plants | Elec. Mach. Design | Industrial Power | Illumination | Electrochem. | Elec. Ry. | Tel. and Tel. | Radio | Electronics | Heat Power | Machine Design | Shop | Structural Design | Hydraulics | Surveying | Railway | Engineering Materials |
| Alabama Pol | 24 | 5 | 8 | 4e | 4e | 2e | | | 6e | 6e | | 10 | | 4 | | 3 | 3 | | 2 |
| Armour Inst | 34 | 4.5 | 4.5 | | 2 | | | | | | | 9 | 4 | 6 | | 4 | 1.5 | | 1 |
| Brooklyn Pol. Inst | 18 | 3 | | 2 | | 2 | | 2 | 5 | 2 | | 9 | 1 | 2 | 2 | 3 | | | 1 |
| Univ. of Cal | 18 | 5 | 4 | 3e | | | | | 5 | 6e | | 9 | 2 | 4 | | 6 | 6 | | |
| Carnegie Inst | 33 | 2 | 5 | 9 | | | | | 2 | 3 | | | | 7 | | 3 | 2 | | 4 |
| Case School | 27 | 5 | 1 | | 3e | 6 | | 1 | 3 | | 3e | 7 | 3 | 2 | | 3 | 3 | | 1 |
| Cornell Univ | 33 | 3e | 3 | 4e | 2e | 2e | | 2e | 4e | 3 | | 11 | 4 | 4 | | 2 | 3 | | 6 |
| Georgia Tech | 24 | 3 | 5e | 2 | | 3e | | 5e | 2 | 3e | 3 | 8 | | 3 | | 4 | 2 | | 2 |
| Harvard Univ | 16 | 7 | | 3e | | | | | 3e | 3e | 3 | 8 | 4 | 1 | | 3 | | | 4 |
| Univ. of Ill | 22 | 3e | 4 | 2 | | 1e | | | | 6e | | 11 | | 6 | | 3 | | | |
| Univ. of Iowa | 22 | 6e | 5e | 3 | | 3e | | | 6e | 3e | | 5 | | 3 | | 2 | 3 | | |
| Iowa State | 24 | 2 | 2 | 2e | | | | 2e | 2 | 2e | | 8 | | 4 | | 3 | 2 | | 2 |
| Johns Hopkins | 30 | 2.5 | 2.5 | 4 | | 2.5 | | 2.5 | | 5 | | 13 | | | | 3 | 3 | | 3 |
| Univ. of Kansas | 15.5 | 4 | 3 | | 3e | 2.5 | | 2e | 5e | | | 6.5 | 3 | 4 | | 3 | 3 | | 1 |
| Kansas State Ag | 26 | 3e | | 3 | | 3e | | | 3 | 3e | 1e | 9 | 3 | 5 | | 4 | 2 | | 2 |
| Lehigh Univ | 25 | 6e | 3 | 6e | 2e | | | 3e | 3e | 3e | | 8 | | | | 3 | 4 | | 3 |
| Univ. of Maine | 27 | 3 | 3 | 3 | | 3 | | 3 | 4.5 | 4.5 | | 7.5 | | 3 | | | | | |
| Mass. Inst. Tech | 19 | 5 | 6e | 6e | 3e | 3e | | 6e | 3e | 3e | | 8 | | 3 | | 3 | 2 | | |
| Univ. of Mich | 16 | 4 | 5 | 4 | 2e | 2 | | 2e | 4e | 6e | 4 | 4 | 3 | 2 | 3 | 3 | 2 | | 3 |
| Univ. of Minn. | 27 | 4e | 6e | 4 | 2e | 4e | | 2e | 6e | 6e | 2e | 6 | | 5 | | 3 | | | |
| Univ. of Nebraska | 22 | 4e | 4e | | | 2e | | 3e | 4e | 3e | | 7 | 6e | 6e | | 3e | 6e | | |
| Ohio State Univ | 20 | 2e | 2e | 4e | | 4e | | 3e | 6e | 3e | 2 | 6 | 6 | 6 | | 2 | | | |
| Penn. State College | 20 | 5e | 2e | 2e | 2e | 2 | | 3e | 3e | 2e | | 10 | 4 | 4 | | 2 | 1 | | 2 |
| Univ. of Pittsburgh | 17.5 | 3 | 2 | 2 | 4 | 3 | | 2 | 1.5 | 1.5 | | 5 | 4 | 1 | | 2 | 2 | | |
| Princeton Univ | 16 | 2 | 3e | 6 | 2e | | 4e | 2e | | | | 10 | 3 | | | 3 | 2 | | 2 |
| Purdue Univ | 26 | 6e | 6e | 5 | 3e | 3e | | 3e | 6e | 6e | 6e | 7 | | 4 | | 4e | 2e | | |
| Renss. Pol. Inst | 21 | 4 | 3 | 4 | 2 | 2 | 3 | 2 | 1.5 | 1.5 | 3 | 9 | 2 | 8 | 3 | 4 | 2 | 3 | 1 |
| Texas A. & M. | 32 | 3 | 3 | 6e | 3e | 3e | | | 3e | 3e | | 8 | | 2 | | 3e | 2 | | |
| Union College | 28 | | | 3 | | | | | | | | 6 | | | | 3 | 6 | | |
| Virginia Pol. Inst | 18 | 6e | 6 | 3 | | | | | | 6e | | 6 | | 6 | | 3 | 2 | | |
| Washington State | 23 | 5 | 2e | 2 | | 3e | | 3 | 3 | | 3e | 9 | 2 | 4 | | 3 | 3 | | 4 |
| Univ. of Wisconsin | 24 | 6 | 3 | 3 | | 3e | | | 3e | 6e | 3e | 9 | 3 | 4 | | 3 | 3e | | 2 |
| Yale Univ | 32 | 3e | 3e | | 3e | | | | 3e | 3e | 3e | 6 | | | | | 3 | | 2 |

e = elective.

engines and turbines, condensers, internal combustion engines, and the general problem of a power plant. Some time in steam laboratory would be valuable to vitalize the work. It will be necessary to establish the standard ratings, efficiencies, methods of governing, and speed regulation of the prime movers here so that they may be transferred to the electrical courses concerned with the generator.

To chemical engineering we look for a knowledge of the engineering materials with which to work. For general structural and power work every student needs an elementary knowledge of the manufacture and properties of the ferrous and non-ferrous alloys, cements, clay products, protective coatings, fuels, boiler scale, and water softening, together with associated laboratory experience in mechanical working and heat treatment of the various metals, welding practise, protection against corrosion, etc. In addition to these widely used materials which are generally covered in the common introductory course in chemical engineering, the electrical student has a special interest in the silicon steels, in oils and papers, in cold and hot flow materials, in phenol plastics, varnishes, tapes, and mica. Seemingly no course given at the present time covers these materials which are so essential to the electrical designer. They should be included in the more comprehensive list of fundamental materials for an electrical student.

In civil engineering a common basic structural design course may follow some 8 semester hours of engineering mechanics, or the same field may be covered as applied mechanics in the last named department. At the University of Michigan the preparatory design courses in mechanics cover statics, 3 hours; strength and elasticity of materials, 4 hours; laboratory in strength of materials, 1 hour; and dynamics, 3 hours. In a fundamental structural design course we feel that the student should have some elementary training in analysis of stresses, moments and shear, for wood, steel and concrete beams, roof trusses and columns; beams and slabs in reinforced concrete masonry; and introduction to soil bearing theory, bearing power of piling, and settlement, together with some contact with electric welding of frames and machine structures.

For curricula in electrical engineering, the semester hours required in cognate or related engineering subjects are shown in the right hand side of Table IV. While there is almost general agreement as to the necessity for courses in heat power, shop work, and hydraulics, there is evidently a considerable difference of opinion as to the need for training in surveying and in the mechanical features of machine design. Again, almost half of the programs offer no training in engineering materials and only 3 curricula call for a structural design course after a preparation in engineering mechanics.

In view of these differences of opinion among teachers not only as to the subjects to be included in the fundamental training of the student but as to the time spent upon them as well, it is felt that consideration and study and the gathering of suggestions from the practising members of our profession would be very much worth while.

# Control for 3,000-Volt Multiple Unit Cars

**Because of the relatively high voltage used and the necessity of mounting the apparatus in a limited space, many new problems of control design were encountered in the 3,000-volt d-c. suburban electrification of the Lackawanna Railroad. This article describes the construction and operation of some of the more important of the control apparatus developed, and the tests made to assure its suitability to the service for which it was designed.**

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THE 282 CARS on the Delaware, Lackawanna and Western suburban electrified system are arranged to operate as 141 units, each unit consisting of 1 motor car and 1 trail car semi-permanently connected; each motor car has 4 1,500/3,000-volt motors of 235 hp. hourly rating, 2 motors being permanently connected in series. Operating stations are provided at each end of each 2-car unit, 1 on the motor car and 1 on the trail car. Trains are made up of from 1 unit (2 cars) to 6 units (12 cars). The auxiliary control of these cars has been described previously ("Auxiliaries for High Voltage D-C. Multiple Unit Cars," by C. J. Axtell, A.I.E.E. TRANS., v. 49, 1930, p. 1282–6); hence this article will treat only features of the control for the traction motors.

Motor control is of the pneumatically operated cam type with automatic acceleration at the rate of 1.5 miles per hr. per sec. The following control points or steps are provided:

6 accelerating steps with 4 motors in series.
1 running step with 4 motors in series.
5 accelerating steps with 4 motors in series-parallel.
1 running step with 4 motors in series-parallel, full field.
1 running step with 4 motors in series-parallel, shunted field.

The control equipment normally operates with a constant air pressure of 70 lb. but will function satisfactorily at a minimum pressure of 50 lb.

A schematic wiring diagram of this motor and control circuit is shown in Fig. 1. A motor generator set and a 300-ampere-hr. battery furnish power at 32 volts for control, lights, and auxiliary circuits; the control equipment is designed, however, to operate over a range of from 20 to 45 volts. Table I gives a listing and weights of the major parts of the control equipment.

**Table I—Weight of Control Equipment of Lackawanna 3,000-Volt Multiple Unit Cars**

| Equipment | Weight in Lb. |
|---|---|
| 2 pantographs | 2,270 |
| 8 pantograph insulators | 340 |
| 1 main fuse in box | 151 |
| 1 main switch and auxiliary fuse box | 313 |
| 1 line breaker | 583 |
| 1 motor controller | 1,119 |
| 1 set motor resistors | 455 |
| 1 field control switch | 88 |
| 2 inductive field shunts | 1,340 |
| 1 master controller | 75 |
| Total weight of motor car control including dynamotor and field shunts | 11,950 |
| Trail car control equipment | 1,260 |
| Total weight of control for 2-car unit | 13,210 |

## CURRENT COLLECTORS

Current for each unit is collected from the double or twin contact wire by a pantograph trolley on each motor car. Pantographs are of the spring-raised air-lowered type, with:

| | |
|---|---|
| 1. Maximum working range | 10 ft. 6 in. |
| 2. Length of contact surface | 4 ft. 0 in. |
| 3. Vertical movement of collector shoe | 2 in |

Bearings on the main shaft are taper roller self-aligning, with pressure lubrication. Contact pressure of the shoes against the wire can be adjusted from 20 to 35 lb. with a maximum difference of 6 lb. between the pressure exerted with the pantograph going up and that exerted with trolley retracting.

## MAIN FUSE

All wiring and apparatus on the car, except the trolleys, is protected by a compression type main fuse mounted on the car roof (see Fig. 2). The fuse holder has two expansion chambers joined by an insulating tube; the fuse consists of 2 braided copper leads with a connecting link of fusible alloy. The vaporizing of the fusible link creates pressure within the tube; this expels the braided copper leads from the tube and extinguishes the arc quickly, without any noise or flame that can be detected.

Arc rupturing tests were made on this fuse with both inductive loads and short circuits on a 3,000-volt 3,000-kw. motor-generator set built especially for high current testing. From oscillograph tests the times required to extinguish the arc completely after the fuse had melted were as follows:

| Volts | Amperes | Circuit | Time (Sec.) |
|---|---|---|---|
| 3,000 | 3,040 | Inductive | 0.030 |
| 3,000 | 7,000 | Non-inductive | 0.0076 |

The oscillograph record of the first test is shown in Fig. 3.

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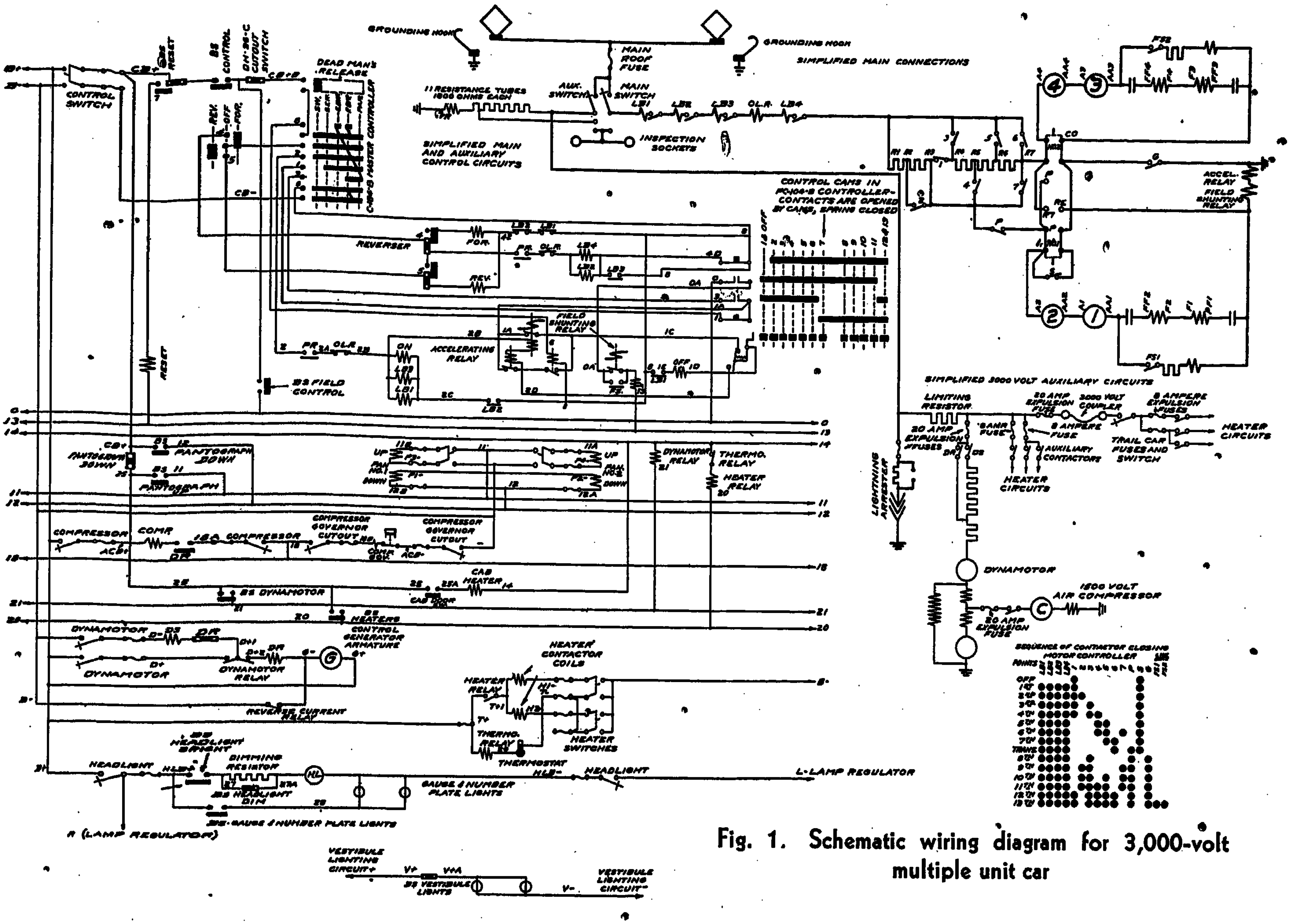

Fig. 1. Schematic wiring diagram for 3,000-volt multiple unit car

## LINE BREAKERS

On these equipments the line breaker is the only device that cuts off the power to the motors; consequently 4 3,000-volt contactors are used in series to rupture normal as well as overload currents. From the standpoint of safety it is essential to have 2 circuit rupturing devices controlled from individual train wires, each device capable of opening the motor circuit; consequently 4 contactors connected in series are used although 2 will interrupt any overload current. The contactors have a nominal capacity of 350 amperes with the blowout coil decreased to 200-ampere capacity to increase the number of turns; the units have $^3/_4$-in. wide tips and a tip gap of 1 in. The contact tip pressure is 70 lb. An overload relay is mounted directly on the back of the No. 4 contactor as shown in Fig. 4.

Oscillograph records made when testing the current rupturing capacity of this breaker show the following times to rupture the circuit after the contact tips begin to part:

| Test No. | Contactors Breaking Circuit | Volts | Amperes | Load | Time Sec. |
|---|---|---|---|---|---|
| 1 | 2 | 3,000 | 4,500 | Non-inductive | 0.017 |
| 2 | 2 | 3,000 | 700 | Inductive | 0.025 |
| 3 | 4 | 3,000 | 1,500 | Inductive | 0.043 |
| 4 | 2 | 3,000 | 1,500 | Inductive | 0.074 |

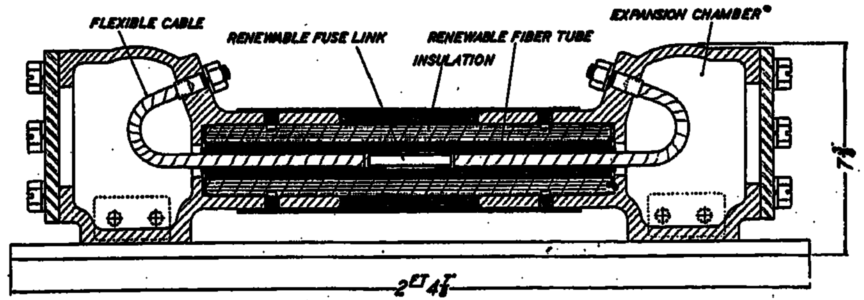

Fig. 2. Cross-section of 3,000-volt main fuse

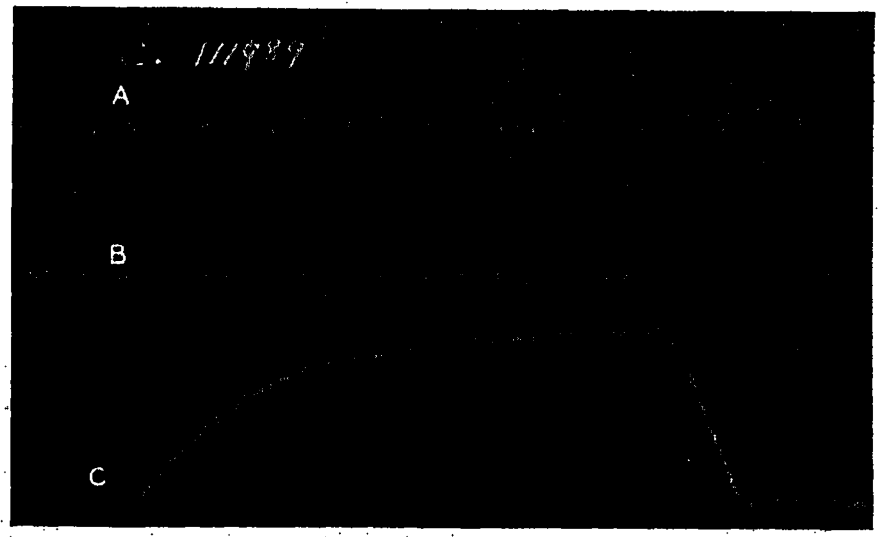

Fig. 3. Oscillograph record of 3,000-volt main fuse rupturing 3,040-ampere inductive circuit

A—60-cycle timing wave; B—Line voltage; C—Line current

The oscillograph record of test 3 is shown in Fig. 5. Interruption tests were made with 2 contactors in series with the following results:

10 interruptions in 2 min. with 3,300-volt 1,500-ampere inductive load.

5 interruptions in 2 min. with 3,300-volt 3,000-ampere non-inductive load.

On account of the liberal design of the line breaker contactors the heating for the service in which they are used is very low. A continuous heat run at 270 amperes gave the following temperatures:

| | |
|---|---|
| Blowout coil | 84 deg. cent. rise |
| Contact tips | 45 deg. cent. rise |
| Flexible shunts | 38 deg. cent. rise |
| Magnet valve coil (operating at 40 volts) | 30 deg. cent. rise |

The line breaker, because of the high voltage circuit and its location on the car, was designed to be grounded to insure safety to any passenger or workman who might come in contact with the box. Grounding this box necessitated some radical changes in insulation and box construction quite different from previous designs on which it has been customary to insulate the enclosing cases.

## Motor Controller and Associated Equipment

The motor controller, consisting of a group of devices assembled in a box for mounting underneath the car, is the principal part of the motor control apparatus. The box is made of fabricated steel with welded joints. Top covers are fixed and all side and end covers are hinged and latched. Cables enter the box at the top through 2-piece wood cleats. The equipment is mounted underneath the car with the box grounded to the car underframe.

A view of the front of the motor controller with the arc chutes of the cam contactors removed is presented in Fig. 6; at the right are the motor cutout switches and on the left are mounted the main air engine and relays. This motor controller contains:

7 cam operated resistance contactors.
3 cam operated contactors for series-paralleling the motor group.
1 main air engine for operating the cam shaft.
1 motor reverser.
2 motor cutout switches.
1 potential or no-voltage relay.
1 accelerating relay.
1 field control relay.

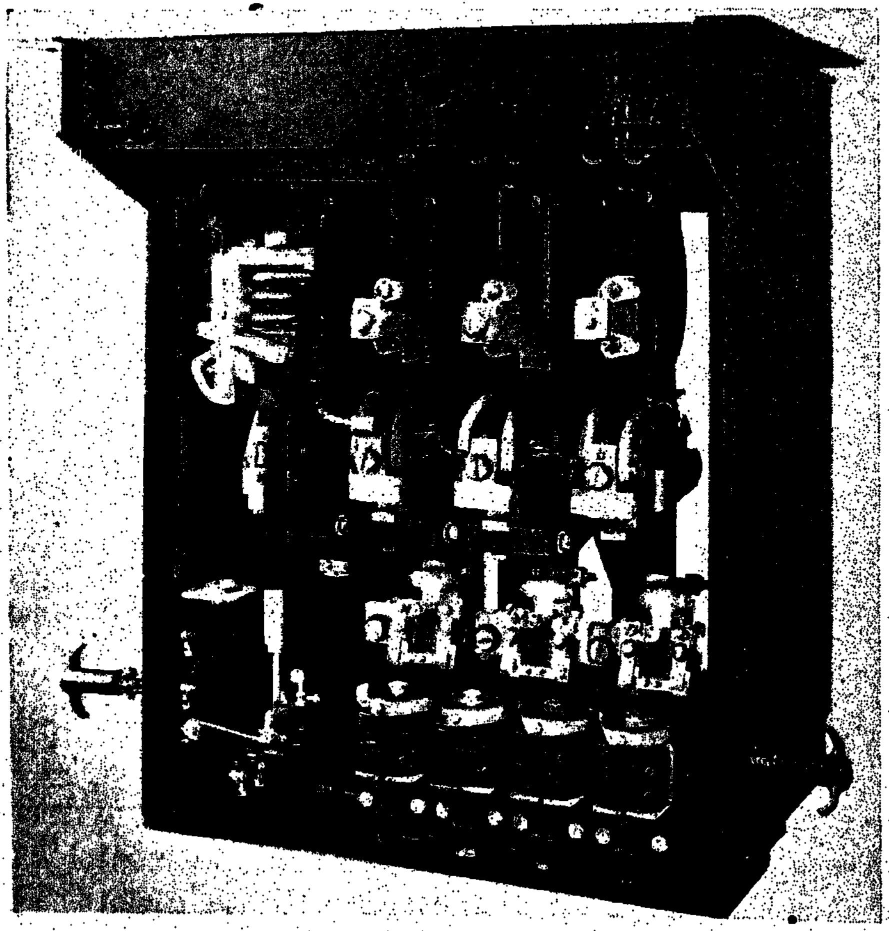

Fig. 4. Rear view of 3,000-volt line breaker

The cam contactors, one of which is shown in Fig. 7, have current carrying parts clamped on a rectangular steel bar which is covered by wrapped insulation. All contactors have magnetic blowout. Current carrying parts are of brass and both upper and lower contact tips are provided with arcing horns. Individual arc chutes can be removed by loosening a single screw at the top of the contactor and rotating the locking mechanism.

Contactors are closed by cams bearing upon a steel roller; they are opened by the pressure of the contact spring and by gravity. Should a contactor tip stick or "freeze," a mechanically operated "knock-out" operates on the cam shaft and mechanically forces the contactor open. Contactors have a 1-in. tip gap and renewable contact tips $^3/_4$ in. wide; contact tip pressure is 16 lb. Two of the contactors (R6 and S in Fig. 1) have enlarged arc chutes vented to the outside of the box as these contactors under some conditions are required to break current. The cam shaft is of hexagonal steel with wrapped mica insulation, cast iron cams being clamped on over the insulation and separated by insulating collars.

An opposed-cylinder air engine operates the cam shaft through a rack and pinion. Air admitted to the "on" cylinder rotates the cam shaft to the "on" position while air admitted to the "off" cylinder stops the progression on any step. Admission of air to the "off" cylinder is governed by a magnet valve under control of the accelerating relay which permits the cam shaft to rotate step by step under the influence of the current through the motors; this maintains a constant average current during acceleration. A specially designed accelerating relay also provides means to enable the operator to advance the motor controller one step at a time regardless of the motor current.

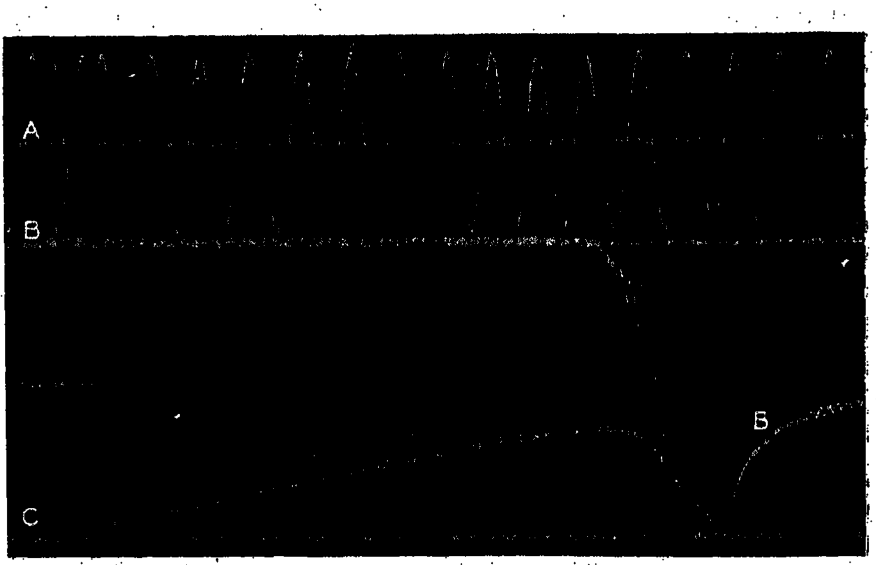

Fig. 5. Oscillograph record of 3,000-volt line breaker rupturing 1,500 ampere inductive circuit

A—60-cycle timing wave; B—Line voltage; C—Line current

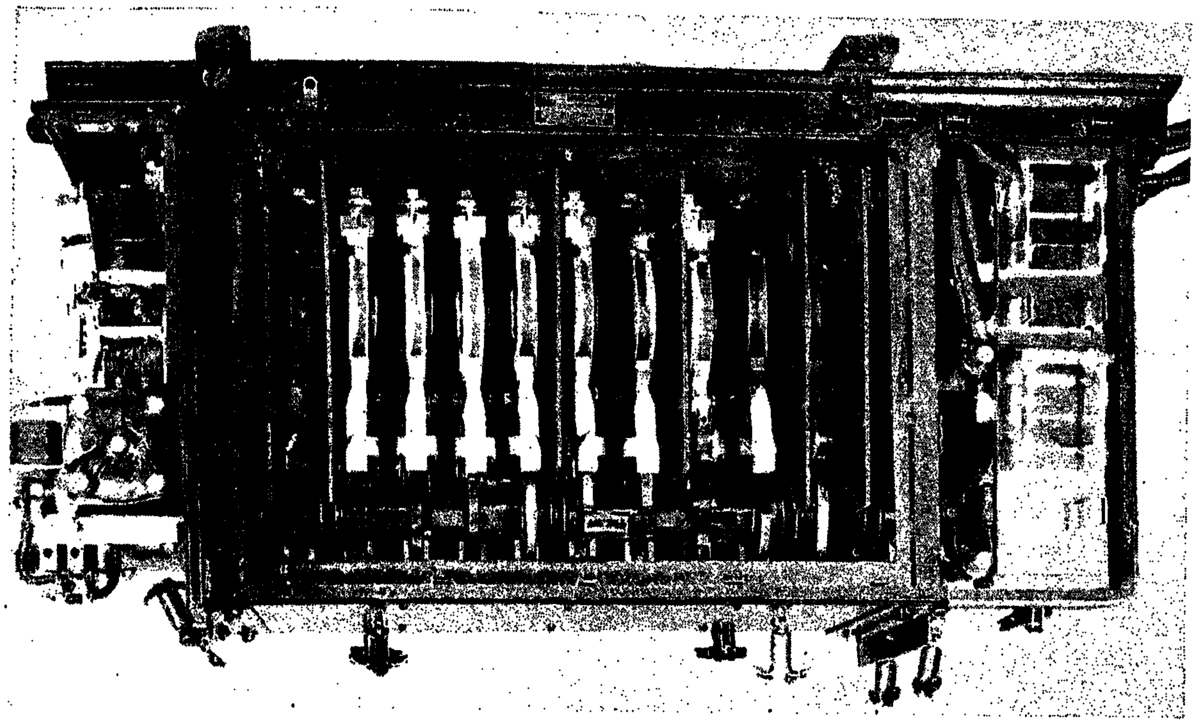

Fig. 6. Front view of motor controller with contactor arc chutes removed

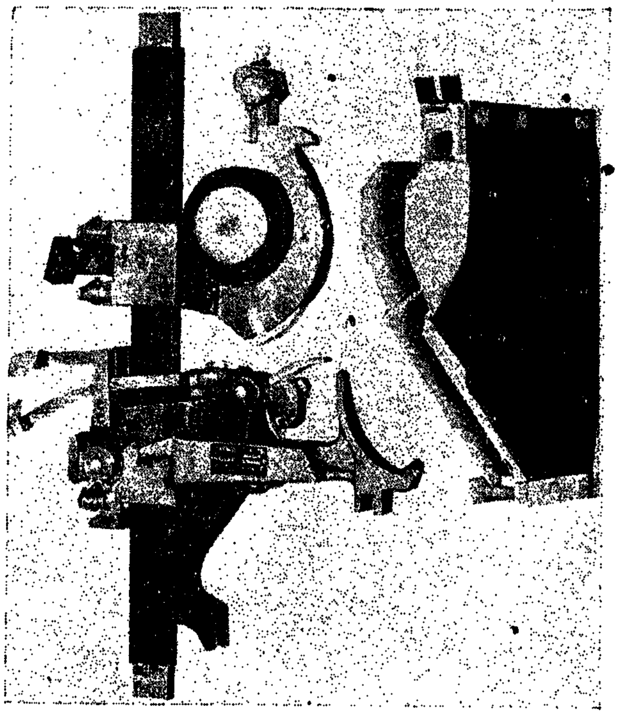

Fig. 7. Cam operated 3,000-volt contactor

Field connections of the motors are reversed by an electropneumatic reverser mounted in one end of the motor controller. It is of the cylinder type with segment castings mounted on an insulated hexagonal shaft. A double cylinder air engine furnishes power to rotate the cylinder to either the forward or the reverse position.

In addition to the accelerating relay there are provided (1) a second relay to govern the closing of the field control switches, and (2) a potential relay with resistor tubes to cut off the control current on an individual car should the line potential fail. The potential relay closes at 1,300 volts and opens if the potential falls to 750 volts.

## Field Strength Reduced by Inductive Shunts

The fields of the motors are shunted by an inductive shunt giving a reduced field strength of 50 per cent. In series with the inductive shunt is an adjustable non-inductive resistance to compensate for any variation in the wiring of the 2 pairs of motors. A separate box with 2 contactors operated by a single air cylinder and having mounted in the back 2 adjustable rheostats composed of edgewise wound units comprise the equipment for shunting the fields.

Main resistors are of the edgewise wound type arranged in 1 group of 2 sections, and 1 group of 3 sections. All of the resistance is connected in the circuit on the trolley side of the motors. The alloy of which the resistors are wound has a high specific resistance, 120 × $10^{-6}$ ohms per cm.$^3$, but a low temperature coefficient of resistance; the increase in resistance is 5.8 per cent with 350 deg. cent. rise in temperature. The resistor frames are insulated from the support by 1,500-volt porcelain bolt insulators; the support is insulated from the car framework by 3,000-volt porcelain bolt insulators.

## Master Controller and Cab Equipment

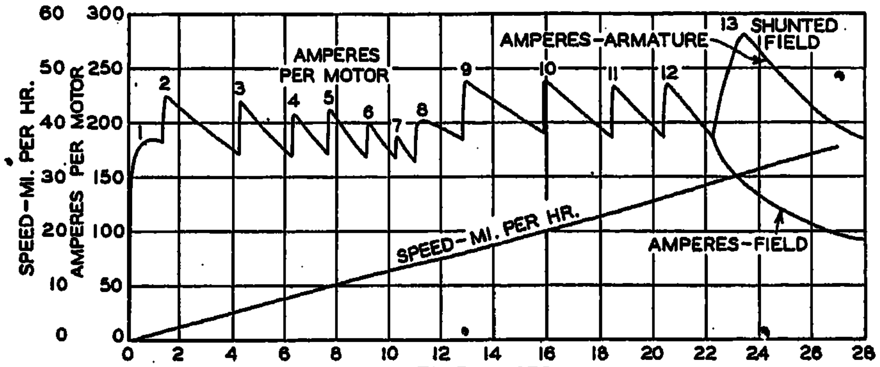

Fig. 8. Acceleration curve of Lackawanna 3,000-volt d-c. multiple unit cars

The master controller has 2 cylinders, a main and a reverse. A "dead man's release and emergency brake feature" is incorporated in the controller which interrupts the control current and actuates a pilot valve to apply the emergency air brakes should the handle be released.

A button type switch in each cab gives the operator convenient control over the pantographs, control equipment, overload reset, dynamotor, heaters, and lights. It is provided with a lock so arranged that all important circuit switches are locked in a fixed position when the key is removed. An additional control switch is connected to the air brake cutout cock; this switch cuts off all control current to the master controller unless the cutout cock is open, thus preventing the starting of the train until the air brakes have been cut in.

## Tests

A sample unit consisting of a motor car and a trail car was completely equipped with motors, control, and air brakes, for test purposes. These cars were run for 15,000 miles on the 3,000-volt test track at Erie, Pa., to determine how they would perform under service conditions.

The production control apparatus was subjected to many special tests. In addition, all control devices for 3,000-volt circuits were given a high potential test of 8,750 volts at 60 cycles for 1 min.; all control devices for the 32-volt circuits were tested at 1,000 volts, 60 cycles for 1 min.

# Sectionalizing Improves Rectifier Efficiency

**By building large capacity mercury arc rectifiers from a group of several small sections, the better efficiency, reliability, economy, and flexibility inherent in the smaller rectifiers can be retained in the larger units. Experiments on a 3,000-kw. rectifier composed of 4 750-kw. units, shows an efficiency one per cent higher than for the conventional single unit type.**

By
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PRACTICABILITY of the sectional type of mercury arc rectifier is based upon the obvious, but apparently heretofore unrecognized, fact that the best possibilities inherent in the device are realized only in the smaller sizes. Efficiency, reliability, economy, and flexibility of both application and use are all far better in small than in large units. Furthermore, the advantages appear to be fundamental and therefore permanent. Subdividing a mercury arc rectifier into unit sections introduces both advantages and disadvantages; but the advantages so far outweigh the disadvantages that, once the conception is considered seriously and the sectional design actually worked out, doubts disappear and sectionalized plan seems the right and natural one to adopt.

Development through the past 29 years has resulted in rectifiers of small capacity, 500 kw. for example, with a high degree of reliability, a reasonable cost, and an efficiency which makes available for the higher voltage applications the unique quietness and freedom from mechanical wear which has been the major incentive throughout the development. When size is increased, however, the quality decreases markedly. Reliability decreases not in proportion to size, but more rapidly because the difficulty of controlling the "hurricane" flow of vapor from the cathode is increased enormously when the size is even doubled. The outage time of 3,000-kw. rectifiers is several times as great as that of 500-kw. units. Cost per unit output does not decrease with increase of size, as it does with some apparatus; this is because manufacturing problems increase faster than in proportion to size, and because the total requirement for this kind of equipment with capabilities and limitations as they are, even in the smaller sizes, will not support organized "line manufacture" for the larger capacities. Efficiency falls off with increase in size because of the longer arc and greater exposure to deionizing surfaces, and because to obtain acceptable quantity the fundamentally less reliability makes necessary an increase in loss-producing arc-back preventives. With present designs, internal losses per unit output for a 500-kw. rectifier are only about $^3/_4$ of those for a 3,000-kw. unit, both based upon 600-volt operation.

## DISADVANTAGES OF LARGE UNITS FUNDAMENTAL

The major disadvantages which go with size appear to be fundamental and permanent, whatever advances may be made. Larger units always will be less efficient, and the reliability and cost disadvantages probably will persist.

Multiple installations of conventional small capacity units of the sort available in the past are impracticable; the space required is too great and the multiplicity of control and protective devices appears highly undesirable. But if a rectifier of large capacity is subdivided so as to take advantage of space economies resulting from recent advances in the art, building the structure in sections but installing, controlling, protecting and using it as a whole, the project becomes feasible; the desirable qualities of the small rectifier are made available for the larger capacities while the disadvantages of sectionalizing are reduced so as to become negligible.

Research in the Westinghouse laboratories on rectifiers of conventional size and characteristics has shown that the limitation in capacity for a given design lies in local limitations of the various parts, for example, the limits of conductivity and heating at the anode, and not in the fundamental and perhaps more troublesome tendency to arc back at the higher currents. To illustrate this the 500-kw. rectifier shown in Fig. 1 carries a nominal current of 833 amperes continuously, 1,250 amperes for 2 hr., and 2,500 amperes for 1 min.; extensive tests, which include use at currents up to 17,000 amperes on short circuit and loads of 2,000 to 2,500 amperes for periods of 5 to 30 min., depending on temperature rise, have not shown arc-back to be a limitation. Extended service experience with a limited number of installations gives the same result. Evidently, changes in the details leaving the general arrangement unaltered, would make it possible to reduce materially the size of the containing tank without affecting the ability of the unit to carry the loads required. Experiments have verified this conclusion.

## SIZE REDUCED BY REARRANGING PARTS

As a further step, a rearrangement of parts made possible a still further reduction in size for a given rating, and at the same time brought about some reduction in the internal losses. The rearrangement was based upon knowledge gained from experiments made to determine: (1) the effect of the way the vapor flows from cathode to condensing wall; and

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Based upon "High Capacity Rectifier Efficiency Improves by Sectionalizing" (No. 32-50) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932.

(2) the effect of the position of the anode structures in relation to this stream of ionized vapor upon the limiting current of which the rectifier unit is capable without excessive arcing-back. Although the whole mechanism of vapor flow and its effect on arc-back still are obscure, several factors that influence performance have been established. In the design shown in Fig. 2 an attempt has been made to take into account in the most satisfactory way possible at the present time, these as yet rather intangible and, it must be admitted, somewhat uncertain factors.

The desirability of improving the anode support and shielding arrangement also offered an opportunity for progress; a rather extended series of experiments resulted finally in the anode structure shown in Fig. 2. Processing to eliminate foreign material and to keep the gas evolution in operation at as low a value as possible, have progressed along with the design development.

As a result of these improvements, the rectifier section shown in Fig. 2 is capable, with a reasonable margin, of a standard nominal rating of 750 kw. at 600 volts, and of even higher short-time overloads at this rating. The unit is required to carry a normal current of 1,250 amperes, and 50 per cent overload, or 1,875 amperes for 2 hr. Since final temperatures are reached in about 2 hr., it is felt that the 2 hr. capacity can best be indicated by continuous operation at the 50-per cent overload value; experimental tests have been made in this way, thus including in a single test some margin of safety along with a degree of acceleration of the test. Double load, or 2,500 amperes, is required by standard nominal rating for a period of 1 min. following full load; experimental tests have been made at this current for a duration as long as 5 min. In all these operations, arc-back is quite infrequent; furthermore, it is a requirement that the rectifier can be put into operation again immediately following such an occurrence.

## Arc-Drop Lower in Sectionalized Rectifiers

Internal losses in the rectifier are determined by the arc-drop, or voltage from anode to cathode during the conducting period; this voltage varies with load current. The value that determines the rectifier efficiency is the average for the various anodes. Fig. 3 shows an average arc-drop curve for both the unit indicated by Fig. 2 and the older, conventional unit shown in Fig. 1. As the size of a rectifier is increased, the arc path becomes longer, resulting in increased exposure to deionizing surfaces; thus the losses per unit output become greater. Experimental rectifiers of 3,000 kw. with a single tank have had arc-drop voltages as shown by the dot-dash curve of Fig. 3. It may be seen that at full loads the difference between the arc-drop voltage of these experimental single-tank 3,000-kw. rectifiers and that of the sectional units shown in Fig. 2 amounts at full load to approximately 6 volts or 1 per cent, on the basis of a 600-volt output. With ordinary load factors and power costs, a 3,000-kw. sectionalized rectifier thus could be operated for from $600 to $1,500 less per year in power cost than could a single-unit rectifier of this capacity; this saving would justify an added investment of from $4,000 to $10,000.

Physical proportions of the sectional units are such as to make it feasible to mount them in service one above another. Thus, a 3,000-kw. unit can be made of 4 750-kw. sections mounted 2 side by side and 2 high, as shown in Fig. 4. Floor space required for such an assembly is approximately 118 in. wide, by 68 in. deep, overall, including auxiliary equipment. The over-all height is 113 in. and the necessary ceiling height of a room to accommodate this equipment need not exceed this value except for electrical clearance of a few inches and whatever may be necessary to provide for adequate working space, certainly not more than 2 ft. It is evident that the sectionalized plan thus makes possible a

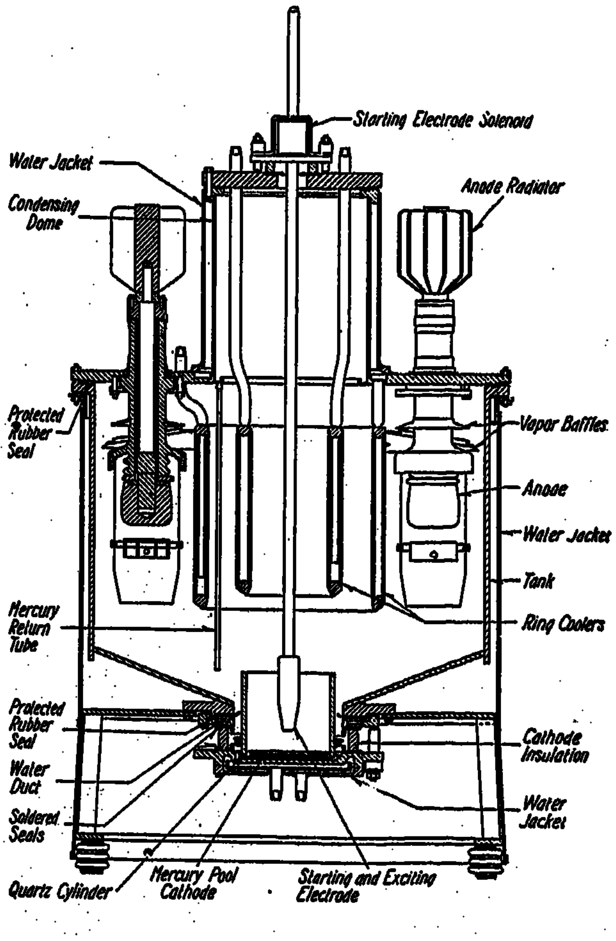

**Fig. 1. (Left) Sectional view of a conventional 500-kw. 600-volt rectifier**

The diameter of each of the 2 units is 54 in.; over-all height of the conventional rectifier shown on the left is 104 in. while that for sectional unit shown on the right is 41.5 in. The kw. rating per unit volume for the sectional unit is thus more than 3 times as great as for the conventional unit

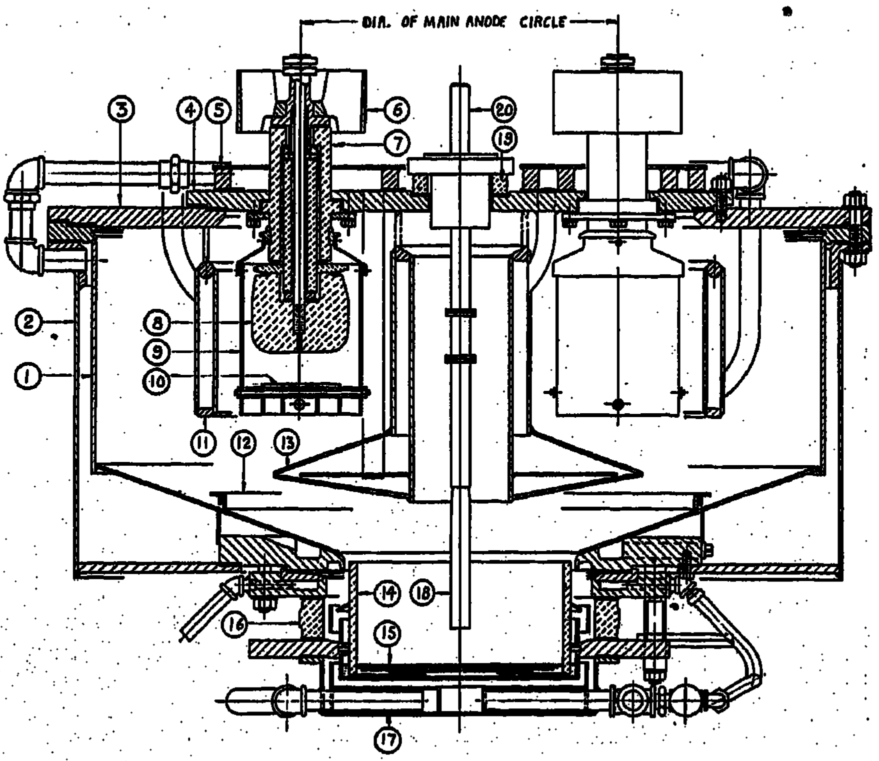

**Fig. 2. Sectional view of an improved 750-kw. 600-volt rectifier unit**

considerable saving in space. Such an arrangement is likely to prove the most convenient for usual applications. There is no reason, however, why other arrangements cannot be used where available space places a limitation on one or more dimensions.

### PARALLELING SECTIONS NO NEW PROBLEM

The problem of paralleling is the same for sectional rectifier units as for a single tank rectifier using the same number of anodes and, except in detail, is the same for any rectifier using twelve or more anodes. Load balancing is inherently approximately correct because the voltage across the arc rises with increasing current after a minimum at about 40 per cent load. To get a closer balance, anode balancing coils are used; these are arranged so as to introduce no appreciable impedance into the circuit under normal operation. Should it be desired to take a section out of service, for maintenance or any other reason, the corresponding balancing coil sections are short circuited by connecting links provided for the purpose.

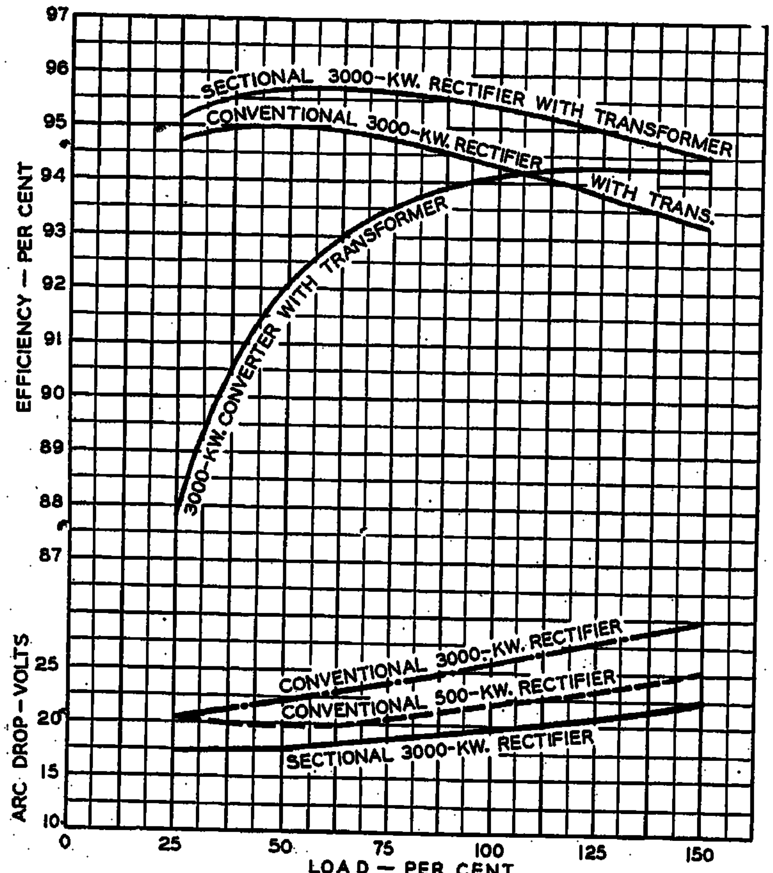

Fig. 3. Comparative characteristic curves for single unit and sectional rectifiers

One arrangement of vacuum pumping for sectional units is indicated in Fig. 5. Use is made of 2 independent pumping systems, connected through manifolding to the various sections and with cross connections so arranged as to permit the use of either pumping system or any or all of the tanks. The various sections of the rectifier are connected to the vacuum manifold through 2 valves of unique design, provided with a sealing plate as an extra precaution against outside air. Even if such a valve should develop a leak, this safeguard would prevent any leakage into the tanks except at a slow rate and only for the minute or less while the valve position is being changed. The use of 2 valves permits the separation of a single section from the balance of the structure without admitting air to either part. When maintenance work is required, it is thus possible to put the repaired section in condition by pretreatment, then install it and, by proper manipulation of the valves, exhaust it completely without admitting air to either the unit or any part of the operating system. With the pumping arrangement shown, this requires the operation of one of the other units with valves closed for some time. This introduces no further difficulty, however, for experience has indicated that if properly made and treated out the rectifier unit will carry normal loads without pumping for several hours or even several days without damage.

Sectionalizing inherently provides the utility

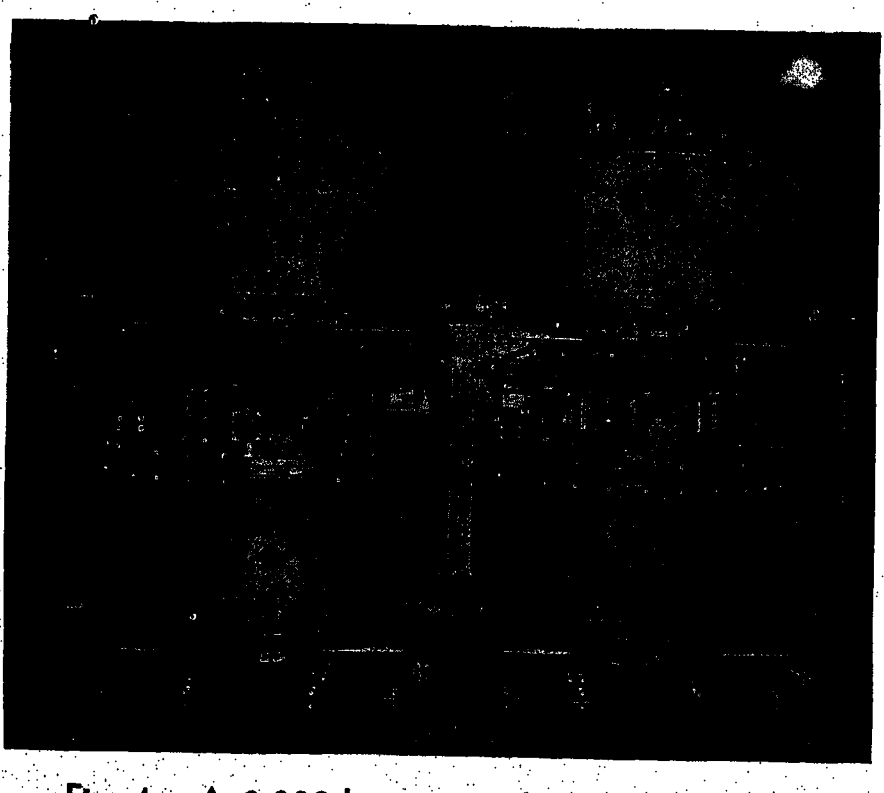

Fig. 4. A 3,000-kw. sectional rectifier composed of 4 750-kw. units

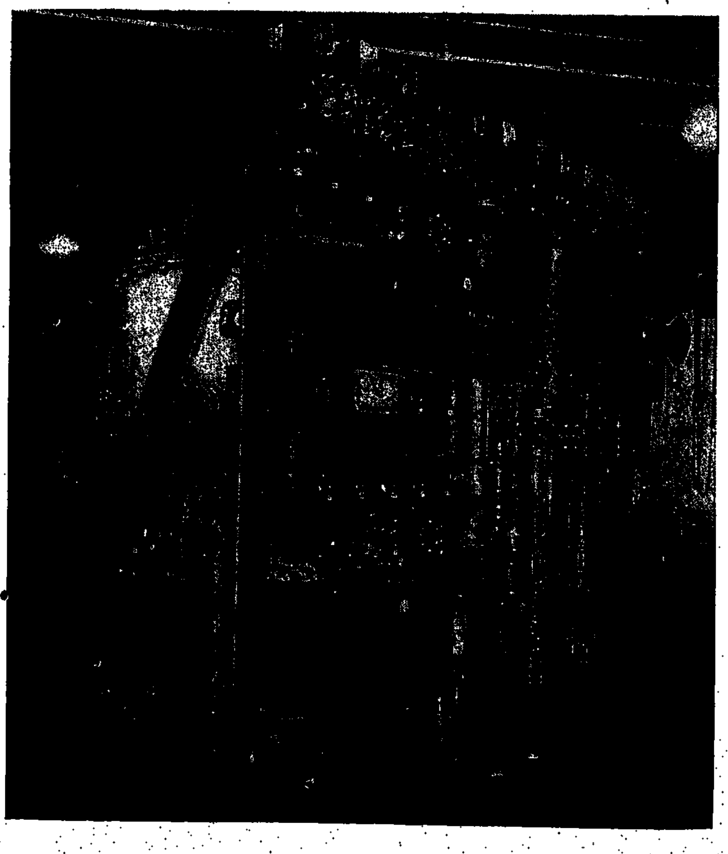

Fig. 5. Rear view of 3,000-kw. 600-volt 4-unit sectional rectifier showing arrangement for maintaining the vacuum

that any damage is likely to be limited to a relatively small part of the total assembly and that during the period of maintenance the load can be carried by the remaining units. With the arrangement shown in Fig. 5, a faulty section can be segregated from the others by removing the connecting links and closing the valves, requiring only a few minutes, before load can be carried again. Although the maintenance operation to remove a unit from the structure for repairs requires as long as 2 hr. or more, this can be done during a light or no load period. It would be possible to arrange with jack connections and separate systems of auxiliary equipment or flexible pumping and water connections, so that the operator could pull the unit forward a few inches and go on with operation with the remainder of the equipment after an interruption of 1 or 2 min. Choice between these 2 plans depends upon cost and service requirements.

The sectionalized plan applied to mercury arc rectifiers, together with development work already performed in designing improved sectional units of more suitable dimensions and proportions, have made available in this equipment increased reliability, increased flexibility in application and use, improvement in manufacturing requirements, and an efficiency advantage of one per cent or more. Beyond this is the belief that further improvements will be made as time goes on and as a clearer understanding is acquired of the fundamental knowledge gained from research. It is to be expected that future developments will progress along the lines of sectional structures rather than single unit arrangements.

# An Improved Gap for Station Apparatus

**An improved voltage limiting gap for protecting electric power station apparatus has been developed, the breakdown characteristics of which may be varied over a wide range so as to conform to the characteristics of the station insulation. For the best protection, a lightning arrester in parallel with the gap is recommended.**

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RECORDS as well as operating experience show that electric power stations may be subjected to a wide variety of transients. Although in practise it is necessary to limit the magnitude of the transients which may cause damage to the equipment, it is desirable that any limiting device shall not function unnecessarily, thereby causing interruptions. This is particularly true where a protecting gap is used that has not the ability to clear the line or prevent the flow of normal frequency current following discharge. This leads to the use of a limiting gap of relatively small time lag for transients of extremely high magnitude and steep front, in parallel with an arrester of greater time lag that will function for the many transients of lower magnitude without interrupting service.

It is exceedingly difficult to coordinate station insulation for the wide range of transients likely to be imposed, as the impulse flashover characteristics may be quite different as regards time lag and polarity, even though these characteristics be in close agreement at normal frequency. This is evident by reference to Fig. 1.

Owing to difference in time lag, a high overpotential suddenly applied may cause one type of insulator to flashover, whereas a transient having a much lower crest value may cause another insulator to flashover. Furthermore, the difference between the

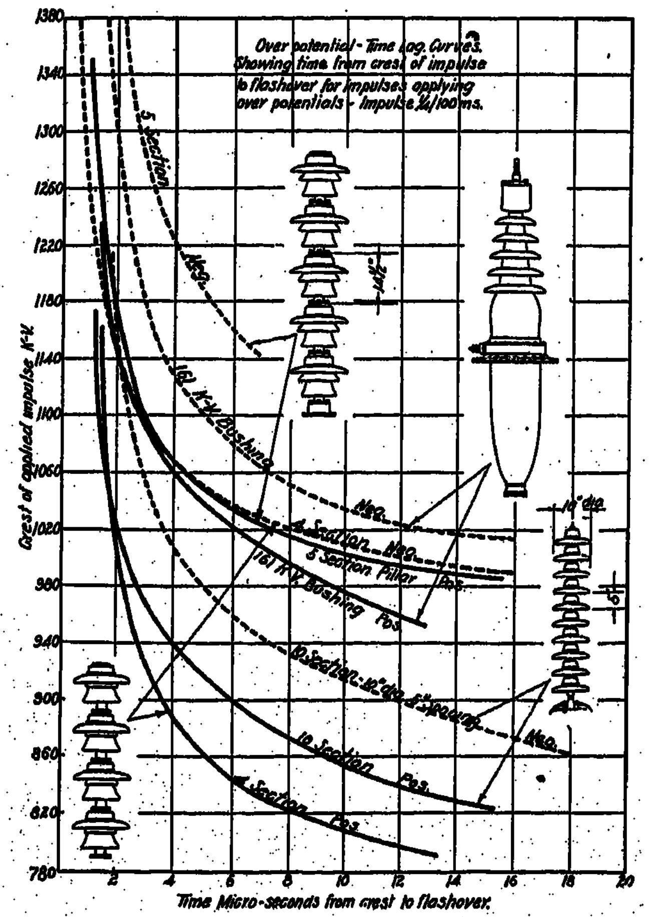

Fig. 1. Impulse flashover characteristics for different types of insulators

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Based upon "Improved Type of Limiting Gap for Protecting Station Apparatus" (No. 32-60) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14–16, 1932.

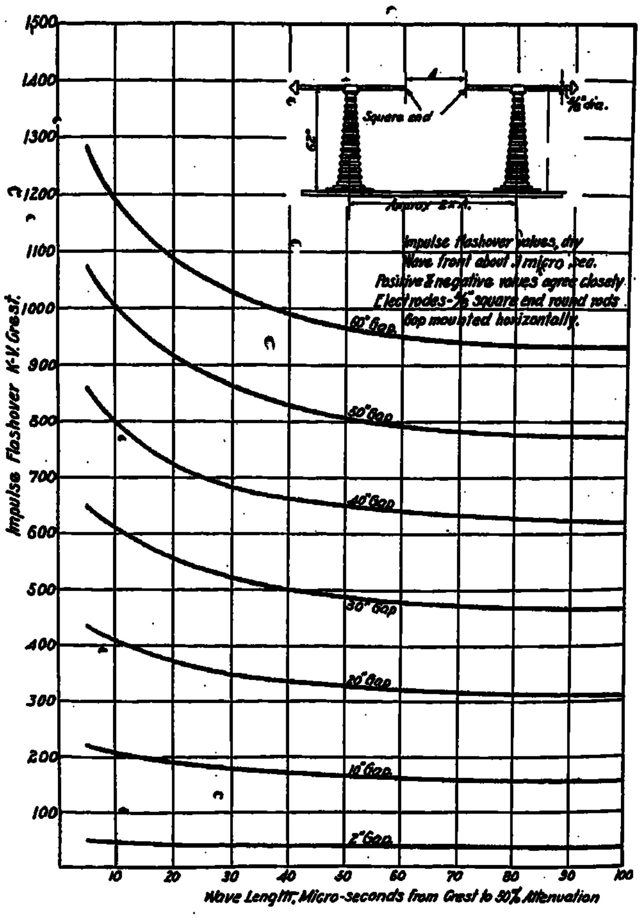

**Fig. 2. (Left) Impulse flashover characteristics for a simple type of gap**

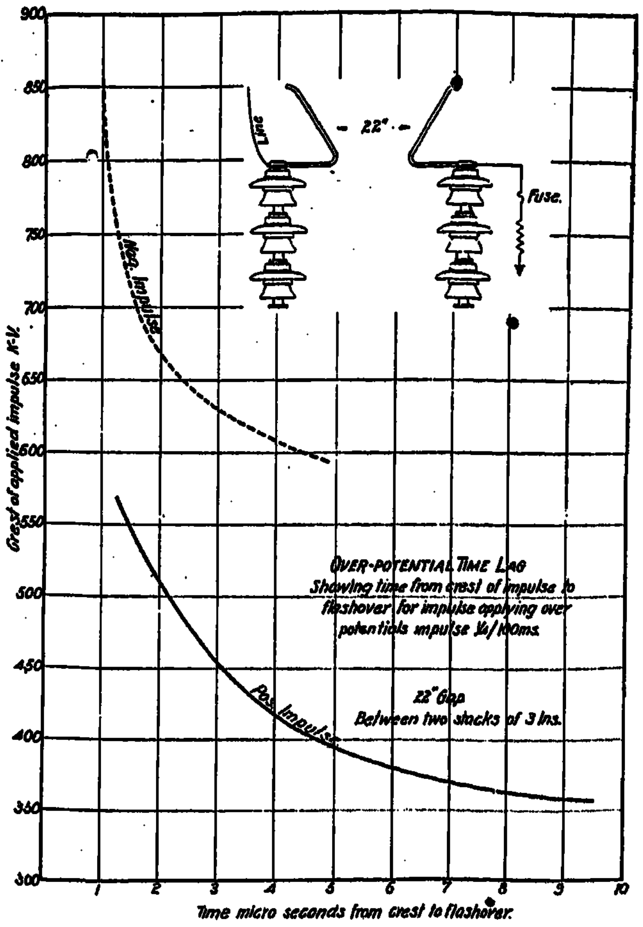

**Fig. 3. (Right) Positive and negative impulse flashover characteristics for a typical horn-gap**

breakdown voltage for negative and positive transients, respectively, may be quite large for bushings, bus insulators, and the internal insulation of transformers and circuit breakers. A bus insulation or a disconnecting switch may have a high effective flashover voltage for a negative impulse, and a much lower value for a positive impulse; for some other piece of equipment the reverse may be true. In station insulation therefore it is necessary to take into account not only the time lag in flashover, but the effect of polarity and oscillations as well.

A lightning arrester or a limiting gap which will protect station insulation against overvoltage transients long has been regarded of great economic importance. It is evident that if a gap or lightning arrester may be depended upon to protect the insulation in a manner similar to that in which a safety valve protects a boiler, it is possible to lower the level of insulation and thereby effect a material saving. To be fully effective, however, the limiting device must interrupt the discharge when the overvoltage is relieved, without interfering with operation.

## CHARACTERISTICS OF LIMITING GAPS

Impulse flashover voltages for a simple type of gap formed by two $^5/_8$-in. rods are shown in Fig. 2; Fig. 3 shows the time lag characteristics for a 22-in. horn-gap. In considering the characteristics of these gaps, it may be noted that the flashover voltage tends to increase rapidly for short waves or for short time intervals. Since equipment needs protection most for severe direct strokes at or in the immediate vicinity of the station, many gaps may not afford the desired protection, although having an arcing voltage comparatively low for less severe impulses or those of longer duration. Also the characteristics of some gaps for positive impulses may be widely different from those for negative impulses. If therefore the gap is to furnish efficient protection, it must have characteristics corresponding to those of the insulation in parallel with it, both with respect to polarity and to time lag.

Impulse time lag characteristics for a typical bushing and several types of limiting gaps are shown in Fig. 4; to avoid confusion, curves for only one polarity are shown. In order to provide protection for the bushing having the characteristics shown in curve *A*, it may be assumed that the voltage limiting gap should flashover at not more than 90 per cent of *A* for all time lags indicated by curve *B*. The characteristic curve of the horn-gap shown as *C* has approximately the same shape as *A*, although it tends to depart somewhat for the shorter time lags. Reference to Fig. 3, however, shows that for that type of gap, the difference between positive and negative sparkover voltages is likely to be very large.

Referring again to Fig. 4 it may be noted that curve *D* for the ring-gap intersects curve *A* at approximately 585 kv. For transients having a crest below 585 kv., the ring-gap will sparkover first; for transients having crest values above 585 kv., however, the ring-gap does not afford protection, as the bushing will sparkover first. Therefore if the ring-gap is set as high as possible so as to minimize unnecessary interruption for transients of lower crest and longer duration, it will afford little or no protection for severe overvoltages when most needed. To provide protection against these severe overvoltages, the ring spacing and flashover voltage must be materially reduced, thereby causing unnecessary interruptions. For example, the minimum flashover voltage shown in Fig. 4 for the ring-gap is approximately 400 kv., as against 520 kv. for the bushing; a further reduction in the flashover voltage of the ring-gap is necessary in order to provide protection for high over-potentials.

Curve *E* of Fig. 4 shows the characteristics of a sphere-gap of negligible time lag having the same minimum flashover voltage as the gap of curve *B*.

As the time of voltage applications is decreased, however, insulators and most equipment will withstand much higher impulses. It is desirable therefore that the impulse flashover of the limiting gap be higher for short time lags. If a limiting gap having the rather uniform flashover characteristics of a sphere-gap as shown by curve *E* is used, unnecessary flashovers will result owing to the sparkover of the gap for the shorter time lags where the insulation can well withstand higher voltages. Characteristics of the sphere-gap may be modified materially by changing the relative sizes of the spheres with respect to each other and with respect to the gap spacing. As will be discussed later, this principle is made use of in the control type of gap to obtain the characteristic of curve *A′*, closely approximating the ideal characteristic curve *B*.

## CONTROL TYPE OF LIMITING GAP

A protecting gap will approach the ideal in so far as the following can be carried out:

1. It should be possible to control the time lag characteristics so that the gap will afford protection over the range of transients likely to be imposed.
2. Negative and positive impulse breakdown characteristics of the protecting gap should correspond to that of the apparatus to be protected.
3. Flashover voltage of the gap should not be lowered seriously by rain or surface contaminations.
4. Means should be provided for changing the relative negative and positive flashover voltages, where it is desired to work within close limits or to protect apparatus or insulation, the properties of which are not fully known.
5. It should be possible to change the time lag characteristics without materially affecting the minimum flashover voltage.
6. Where discharge of the gap will cause a serious service interruption, a fuse or other device should be used for clearing the normal-frequency current following discharge.
7. The gap should not discharge under high frequency transients of comparatively low magnitude caused by switching or arcing grounds.

A gap conforming to these requirements obviously should have improved characteristics over types in general use in the past; development of such a gap is described in the following paragraphs.

A protecting gap using spheres of proper size in relation to the gap spacing and of unequal diameters to provide for the difference in negative and positive characteristics of the equipment protected could be used to comply with requirements 1 and 2 just enumerated. However, the effect of water or other surface contaminations upon the flashover voltage of spheres would make it difficult to conform to requirement 3. Also the characteristics of the gap made in this way could not be changed easily and therefore would not meet the requirements 4 and 5.

As the spacing of a protecting sphere-gap is increased to lengths well beyond the diameter of the spheres, the flashover voltage for a positive impulse will tend to be lower than for a negative impulse. This can be offset by using a larger sphere for the live terminal and a smaller one for the ground terminal. Where the electrostatic fields of the two terminals of the gap are of equal intensity, the flashover will start from the positive terminal since a lower density is required to start discharge with a positively charged electrode. Therefore by controlling the flux density at the surface of a gap terminal, it is possible to vary the discharge voltage. This principle is made use of in the newly developed limiting gap, one form of which is shown in Fig. 4. The control shields in the vicinity of the gap terminals can be moved forward or backward to change the field density and regulate not only the time lag but the difference in negative and positive sparkover characteristics.

Test results (see Fig. 5) show that the relative negative and positive flashover voltages of the protecting gap may be controlled readily by changing the flux density of the positive arcing tip. Any screen or shield may be used to accomplish this. It is important, however, that the shield does not cause erratic performance by becoming one of the electrodes so that an arc will be struck between shields

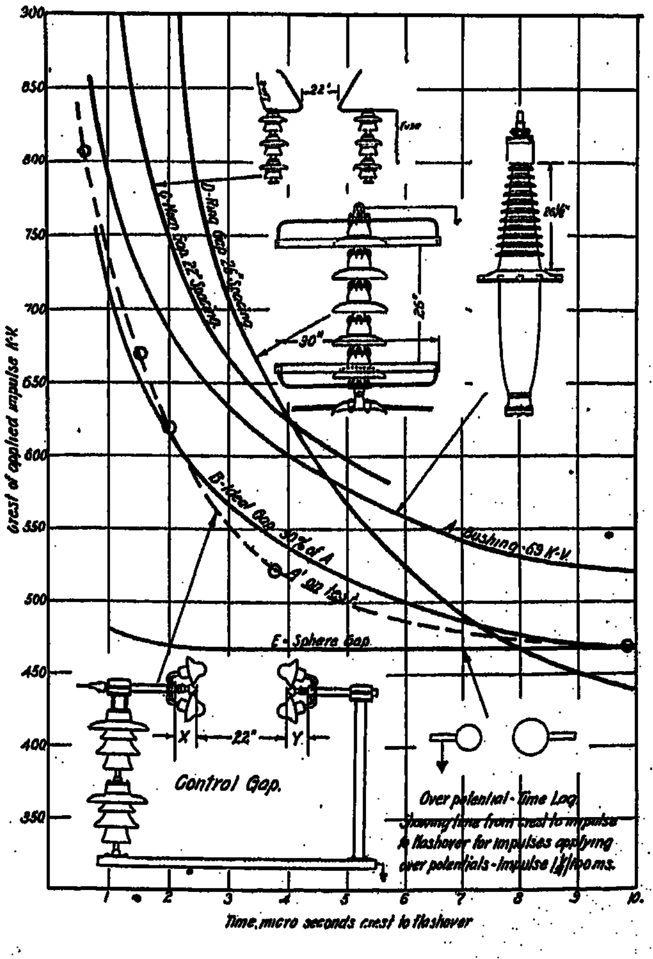

**Fig. 4. (Left) Comparative impulse flashover characteristics for various gaps**

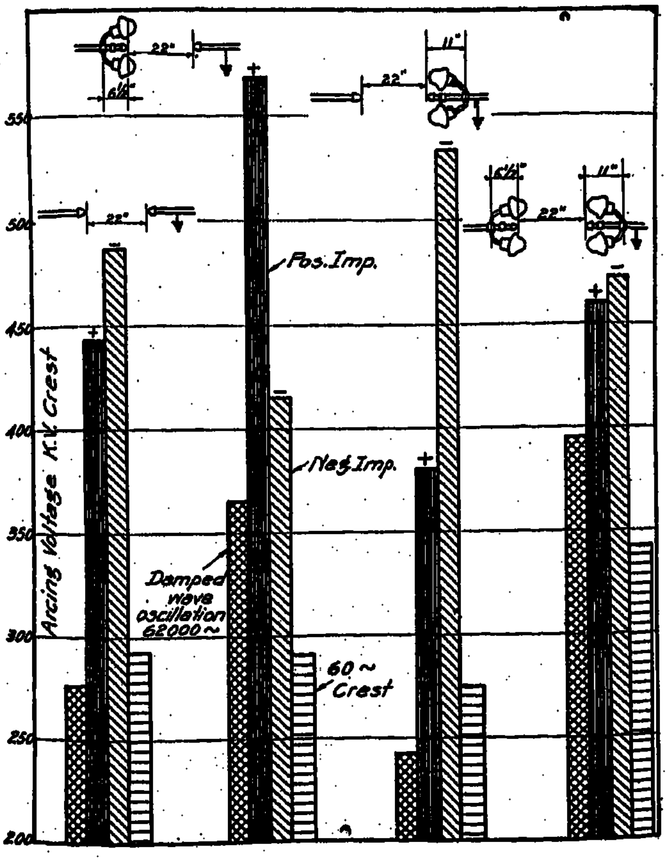

**Fig. 5. (Right) Chart showing effect of insulated control screens upon arcing voltages of a 22-in. gap**

or between one of the tips and a shield. By using the insulated type of shield this difficulty is obviated, even though the shields may be nearer together than the discharge points. This is particularly important in wet conditions or where the gap may be subjected to high frequency oscillations, for in these circumstances a gap having bare metal shields generally has a very low flashover voltage. Reference to Fig. 5 shows that control of the flux density of the discharge points by means of the insulated shields is quite effective in changing the relative arc overvoltage for negative and positive impulses. In addition it may be seen that the arcing voltage for a damped wave or oscillation compares favorably with that for an impulse, thereby reducing unnecessary discharges.

The change in relative negative and positive impulse sparkover voltages that may be effected by changing the flux density on the electrodes with insulated control shields is shown by Fig. 6 as well as Fig. 5. Reference to Fig. 6 shows that the arcing voltage for a negative impulse is approximately 75 per cent greater than for a positive impulse where the controlled screens have the same relation to the arcing tips, and where the control screens are well forward ($C = 3$ in.). Moving the control shield on the ground electrode back from the point of the gap reduces the screening on this electrode so that the discharge will start at a lower voltage for a given distance between terminals when the opposite terminal is negative. Moving the shield back on the ground side also reduces the flux on the live terminal so that the arcing voltage for a positive impulse will be raised. For example, by increasing $C$ to 9 in. and reducing the screening effect of the control shield on the ground electrode, the positive and negative impulse values are brought in close agreement. Advancing the control screen on the live side toward the gap opening has the same general polarity effect as moving the control screen on the ground side away from the gap opening.

It is evident that the arcing voltage will be increased for a given gap spacing if the stress on the arcing tips is reduced by advancing the control shields; this makes it possible to reduce the gap spacing and time lag for a given flashover voltage. It necessarily follows that the characteristics of the gap may be changed materially, both as to time lag and the effect of polarity upon discharge voltage, by simply adjusting the control shields. As the projecting insulated control screen is affected but little by high frequency transients, it is possible to reduce the time lag without lowering the flashover voltage for waves of lower crest and long duration. In Fig. 7 the impulse flashover values for waves of different attenuation are given for a control type of gap and a ring equipped suspension string, respectively.

Control gaps of this type may be made in several different forms with plain shields or rings used in place of the insulated control screen. The latter has the advantage in that the gap does not have a low flashover voltage for oscillations and is affected but little by rain or conditions which may cause a gap with a bare metal shield to be erratic. Other forms of gaps embodying the principles outlined in some cases may work out to much better advantage.

## CONCLUSIONS

Results of this study and development work indicate that:

1. An ideal voltage limiting gap for station use is one wherein both polarity and time lag characteristics are capable of adjustment over a sufficient range to allow protection of all apparatus in parallel with it for any transient wave form imposed upon the station.

2. A form of limiting gap has been developed, making use of adjustable electrostatic field controls for the gap electrodes. This allows the breakdown characteristics of the gap both as to time lag and arcing voltage for positive and negative impressed waves, to be varied over a wide range so as to conform to the characteristics of the station insulation.

3. The use of a control type of gap for limiting the severest transients only, and a lightning arrester for the remainder, undoubtedly will provide the best station protection and operation available at present.

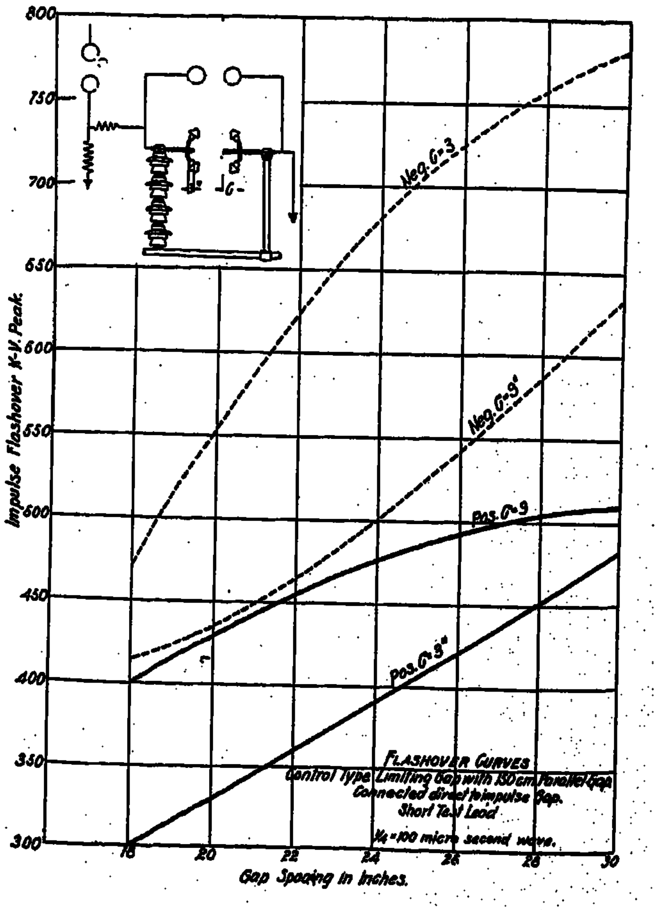

Fig. 6. (Left) Impulse flashover characteristics for a shielded gap with different adjustments

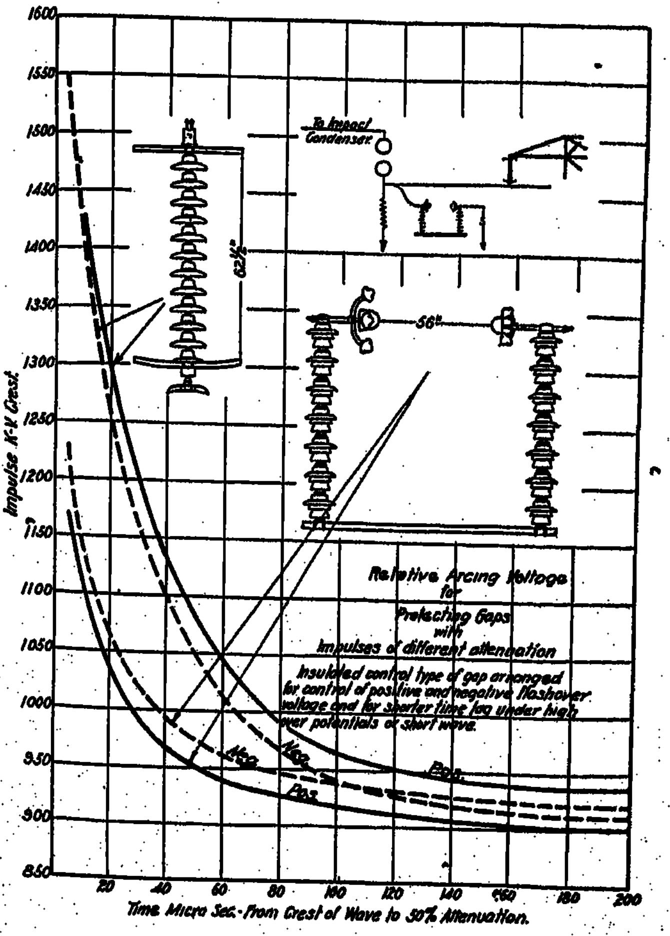

Fig. 7. (Right) Comparative arcing voltages of protecting gaps with impulses of different attenuation

# Abstracts

## Of Papers to Be Presented at the Pacific Coast Convention

INTERPRETIVE abstracts of all papers which at the time of this issue are definitely scheduled for presentation at the A.I.E.E. Pacific Coast convention (Aug. 30–Sept. 2, 1932) are published herewith. In response to popular demand and within its space limitations ELECTRICAL ENGINEERING subsequently may publish certain of these papers, or technical articles based upon them.

Members vitally interested and wishing to obtain a pamphlet copy of any paper available in that form may do so by writing to the A.I.E.E. Order Dept., 33 West 39th Street, New York, N. Y., stating title, author, and publication number of each paper desired.

### The Power System of the British Columbia Power Corporation, Ltd.

By
E. E. Carpenter[1]

THE SYSTEM LOAD of the British Columbia Power Corporation, Ltd., is concerned principally with lighting, domestic power, and small industrial power. With one exception no heavy contract load is carried. Owing to the seasonal and climatic influences the load factors are inherently low, the annual load factor ranging for several years between 45 and 48 per cent, with little immediate prospect of improvement. The peak load on this system, during the middle of December, is 100,800 kw.

The power supply for the system is derived principally from hydro sources although 3 steam plants are maintained for standby, emergency, and occasional peak service. The coastal region especially is favored in water power resources, although precipitation increases rapidly with altitudes any distance from the coast. Snow and ice on the higher elevations and dense forest growth over a large part of the area have a considerable effect on the power supply, while the glacial structure and topography lend their aid to providing favorable dam sites and storage basins for regulation, a necessary and expensive part of all the developments.

Details of the electric, hydraulic, and structural features of the principal generating plants of the system are described briefly in this paper, and the transmission and distribution system is summarized. (For presentation only; not scheduled for publication by the Institute.)

### Segregation of Hydroelectric Power Costs

By
W. S. McCrea, Jr.[3]

THE PRODUCTION COST of electric power is made up of the power or demand cost per kilowatt and the energy cost per kilowatt-hour. The relative amount of each of these items which make up the total cost of power at the power station determines the cost at any load factor. The above segregation of the annual production cost of power is essential in determining the power rates and the economic design of the production plants of an electric system.

The usual hydroelectric power station is designed to utilize as much of the potential stream flow energy as is possible economically with the type of load available. The annual costs of such a station having storage may be divided between those costs proportional to the generating capacity and those independent of the generating capacity. For use in the design of the station the energy available in the stream is fixed at some value, and is determined by the stream flow records. The energy cost of hydroelectric power from this type of station is the annual costs which are independent of the generating capacity divided by the useful stream flow energy. The demand cost is the annual costs which are proportional to the generating capacity divided by the power or kilowatts. This method of analysis is applicable to the majority of hydroelectric developments. The nature of a hydroelectric station is such that the factors that fix the cost of power are those which give an average cost over a period of years.

The discussion in the paper is divided into 3 sections. The first section is a brief outline of the method used in segregating system power costs and the development of the fundamental cost items. The second section has to do with the segregation of the power costs of hydroelectric stations into their component parts; the methods of developing the components for different classes of hydroelectric stations are outlined. In the last section the peculiarities of hydro power are given and the method of determining an average cost of power for a hydroelectric unit or system is outlined. (A.I.E.E. paper No. 32-112)

### The Reading Company's Philadelphia Suburban Electrification

By
G. I. Wright[4]

THE ELECTRIFICATION of the Reading suburban service in the vicinity of Philadelphia was first placed in operation July 26, 1931. The lines now under electrical operation include 65 route miles and 157 track miles, which will be increased by January 1, 1933, to 87 route miles and 203 track miles. These lines consist of 6 branches and cover all the suburban territory north of Philadelphia, between the Schuylkill and Delaware rivers.

Severe competition from automobiles, buses, a new subway, and the Pennsylvania Railroad's electrified lines had resulted in serious loss of traffic and revenue to the railroad. The Reading Company was faced with the alternative of impairing the existing steam operation to reduce costs, or providing a modern superior electrified service. The latter policy was decided upon and electric operation has now been in effect over a year. In spite of a 20 per cent speeding up of schedules and an increase in trains and train miles of approximately 100 per cent, the cost of operation is found to be substantially lower than for the service by steam in the same territory. The improved schedules combined with greater cleanliness and more attractive equipment have changed a steady loss in traffic into an appreciable increase. As a result, the railroad management recently authorized the electrification of the suburban service on its Norristown branch from Philadelphia to Norristown.

The present paper describes the electrification, giving details of power supply, substations, catenary structures, signal bridges, transmission lines, and catenary system, and rail return system. Considerable information is given also on the multiple unit cars, together with motors and control. Interchangeability of apparatus was given special consideration during design, and many special features have been incorporated. (A.I.E.E. paper No. 32-109)

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[1] British Columbia Electric Railway Company, Ltd., Vancouver, B. C.

[3] Department of Public Works, State of Washington, Olympia.

[4] Reading Company, Philadelphia, Pa.

## Electrical Operation on the Cascade Division of the Great Northern Railway

By
J. B. Cox[5]

ELECTRIFICATION of the Great Northern Railway's main line between Skykomish and Wenatchee, 73 route miles, was carried out in conjunction with the building of a new tunnel 7.79 miles long, and the relocation of approximately 17 route miles of troublesome track and other minor improvements, aggregating an expenditure of approximately $25,500,000. Although all of these improvements were placed in operation at about the same time, making a direct comparison of operating expenses difficult, analyses which give a reliable comparison between the cost of steam and electric operation over this part of the system have been made.

Operating difficulties with this recent electrification, especially those occurring shortly after the equipment was placed in service early in 1929, are described in this paper. Some of these difficulties were due to the condensation of moisture caused by the sharp changes in air temperature at the upper end of the tunnel and toward which the draft of air flowed. Other changes in the locomotives and control were found desirable and are described.

Segregated operating costs with steam and electric operation are presented, and show that although the route miles with the present electrified section are only 8.8 per cent less than the route miles with the previous steam operated section, the total operating costs are reduced 57.3 per cent. Costs of the electrification also are presented. (A.I.E.E. paper No. 32-110)

## Theory of the 3-Wire D-C. Generator With 2-Phase Static Balancer

By
E. G. Cullwick[6]

AN ANALYSIS of the theory of the 3-wire d-c. generator using a 2-phase static balancer is presented in this paper with the particular object of explaining the very large unsymmetrical magnetizing current peaks which occur in the balancer windings. These peaks are evidence of unsymmetrical flux variation attaining high values of flux density; and as their value may be equal to, or greater than, the total unbalanced current in the neutral wire of the system, they have a pronounced effect upon the r.m.s. value of the currents, and therefore upon the heating, in the balancer phases. They also cause marked pulsations in the terminal voltages of the machine.

These magnetizing current peaks are out of all proportion to the actual magnetic unbalance of the 2 phases on the balancer core; and the mathematical development shows that they are cumulative phenomena, analogous in a general way to the cumulative growth of field current in a shunt generator, and depending for their initiation upon only a very small magnetic unbalance of the balancer phases, and upon a normal maximum flux density which lies above the perfectly straight portion of the magnetization curve for the balancer core.

An expression for the e.m.f. induced in the balancer phases by the alternating flux in the core is obtained. From this are analyzed the conditions governing the cumulative growth of the current peaks until a steady value is reached. It is found that any unbalance of the resistance of the balancer phases has a marked effect upon the phenomena, it being possible by the introduction of a suitable unbalance to cause the peaks to reverse. If the resistances of the 2 phases are kept equal, it is found that the value of the current peaks decreases with the increase in the resistance of the balancer windings.

These theoretical conclusions are verified by oscillograms, which, taken on an actual machine, clearly show the nature of the phenomena and their variation with the operating conditions of the machine. (A.I.E.E. paper No. 32-111)

## Metering of Symmetrical Components

By
R. G. Shuck[7]

CONTENTS of previous publications on metering of symmetrical components have been confined to the components of current and voltage in 3-phase 3-wire systems. This paper discusses the method of metering the positive and negative sequence power and energy in 3-phase 3-wire systems, and positive, negative, and zero sequence power and energy in 3-phase 4-wire systems. Networks are described which make it possible to meter these components simultaneously and separately. Tables are included showing the location and number of instrument transformers required for each network. Equations involving the design of the impedances of the metering systems are given.

In discussing the various metering systems, the possibility is suggested of metering large blocks of power at the alternator terminals with 1 wattmeter, a positive sequence network, 2 potential transformers, and 2 current transformers, used to replace 3 wattmeters, 3 current transformers, and 3 potential transformers. Also it is suggested that in relay and control equipment the components of power be utilized as well as the components of current and voltage. Where definiteness of action depends upon the amount of voltage available at the relay, positive and negative sequence components of power might be utilized in the relay. One relay using the balanced components of current and voltage will function regardless of which phase is short circuited.

A preliminary design of a complete set of network impedances necessary for simultaneous metering of positive and negative sequence power reveals that the equipment could be placed in a box having dimensions of less than 6x6x6 in. (For presentation only; not scheduled for publication by the Institute.)

## Shaping of Magnetization Curves and the Zero Error Current Transformer

By
A. C. Schwager[8]
V. A. Treat[8]

NONE of the methods previously available to improve transformers is capable of producing an important requirement of the power industry; namely, the high accuracy, high voltage, low ratio, bushing type current transformer operated at a high secondary burden. However, in analogy with the molecular theories of magnetization, a method of shaping magnetization curves has been advanced for securing constant permeability. Tests prove this method to be very effective and to result in a permeability which remains constant within fractions of one per cent over a wide range of induction.

The method has been applied to the bushing or through type current transformer so desirable for the metering of high voltage transmission lines. For this type of transformer the exciting current of the core in the low flux density range of its normal operation has a

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5. General Electric Company, Erie, Pa.
6. University of British Columbia, Vancouver, B. C.
7. University of Washington, Seattle.
8. Pacific Electric Mfg. Corporation, San Francisco, Calif.

nonlinear characteristic. However, a much smaller core of varied cross-section, working at a higher flux density, can be made to have an exciting current characteristic of almost exactly the inverse curvature and similar value to that of the current transformer core.

If a reactor with such a core be connected in parallel with a current transformer secondary, the total exciting current of the combination can be brought to an almost exact linear relation with the secondary voltage or current for a considerable range of values. This linearity produces a like relation as to primary and secondary currents. The loss of secondary current due to the parallel reactor is restored by reducing the number of secondary turns to bring the transformer to a desired ratio, and the phase angle discrepancy is corrected by neutralizing the major part of the exciting current by the reactive current of a parallel capacitor. A parallel resistor has a similar effect but the sensitivity of the transformer to burden variations is increased.

Current transformers with this auxiliary equipment (transformer compensator) are adjusted for a fairly large burden, such as 50 voltamperes and 0.50 power factor. A variable loading burden (burden compensator) is placed in the secondary circuit so that a considerable range of external burden is possible without affecting the calibration curve of the transformer.

A 115-kv. bushing type transformer with a silicon-iron core when thus equipped will give characteristic curves between 0.5 and 5 amperes secondary current not exceeding variations of 0.001 in ratio correction factor and 10 min. of phase angle. Greater accuracies than this are possible if required commercially.

High precision wound type current transformers also may be secured by this method at no substantial increase in cost or complication of construction. In the same manner zero error potential transformers and watt-hour meters, relays with prescribed characteristics and linear electric circuits including ferro-magnetic cores, are easily produced. **(A.I.E.E paper No. 32-116)**

## Factory Assemblies in Substation Design

By
M. H. Hobbs[9]

DESIGNS and factory procedure for factory assemblies of medium voltage substations which may be applied to either network or radial distribution systems are described in this paper. These substations may be divided roughly into 2 principal classes, those for serving large individual power consumers and those for general distribution to a community of varied customers. In the latter class may be included also substations in very large industrial plants and steel mills having their own generating and transmission systems.

For so-called customer substations of the indoor type, the special requirements are usually limited space, low cost, safety, and simplicity. Metalclad switchgear offers an ideal factory assembly for the high voltage side of such an installation, occupying as it does the minimum floor space both for installation and for operating aisles. From the low voltage side of the transformers a metal enclosed bus run is desirable, terminating in a metal enclosed structure with transformer and feeder air circuit breakers of either the draw-out type or the fixed type. In addition to the metalclad construction, truck type and cubicles are available in factory assembled construction. Customers' outdoor substations, comprising mainly the high voltage switchgear and transformers, also are available in this construction.

Substations for general distribution differ from so-called customer's substations largely in number of circuits, complexity of bus arrangement, and amount of meter and relay equipment used; otherwise similar apparatus may be used for both applications. Space may be at a premium on account of the larger amount of equipment to be accommodated, and in any case it is desirable of course that ground space cost be kept as low as possible.

It is in the wholly outdoor form of substation that the greatest saving from the use of factory assemblies can be effected, since a further saving comes from the elimination of the building. This applies whether the station is for a network or radial system. Cost analyses of factory assembled substation layouts show surprising over-all economy. **(For presentation only; not scheduled for publication by the Institute.)**

## High Voltage Oil Circuit Breakers

By
R. E. Rowley[10]

MECHANICAL maintenance of high voltage circuit breakers is of considerable importance to the successful operation of power systems. Experience obtained over a number of years has proved that in many ways existing equipment may be modernized and betterments provided by the operating engineer.

Some of the problems which have been encountered in maintaining and rebuilding high voltage oil circuit breakers in connection with a modern and fast growing system are indicated in this paper. It has been found that high voltage circuit breaker maintenance may be improved materially with the use of available apparatus such as the tuning fork and equipment for securing travel-time curves. Information obtained from such studies automatically will indicate whether improvements to the switchgear are necessary.

In the paper, details of the changes made to existing equipment are discussed; these include improvements in the solenoid, safety, and venting, and various other mechanical changes to give greater current carrying and interrupting capacities. The economy of rebuilding obsolete switches has been proved. In many cases, the rebuilding of switches has cost considerably less than new switches, and subsequent performance has been quite satisfactory, as all operations have compared favorably with those of newer equipment. **(For presentation only; not scheduled for publication by the Institute.)**

## Corona Loss Measurements for the Design of Transmission Lines to Operate Between 220 Kv. and 330 Kv.

By
J. S. Carroll[11]
Bradley Cozzens[10]

DURING the summer and fall of 1931, measurements at the Harris J. Ryan Laboratory, Stanford University, Calif., extended the range of corona loss data for conductor sizes beyond those investigated during 1930. In these latter tests the 3 conductor specimens studied were a 1.125-in. hollow copper cable, a 1.49-in. hollow copper cable, and a 2.0-in. hollow aluminum cable. The losses were measured on a 3-phase line 700 ft. long. Voltages as high as 600 kv. between lines were used. The conclusions obtained in these tests are summarized as follows:

1. There are throughout variations in corona loss that result from causes at present unknown. These variations are of sufficient magnitude to be considered in the design of transmission lines and should be remembered when studying corona loss data.
2. Further evidence proves that the die, grease, and other foreign matter existing on cables as received from the manufacturers greatly increase the corona loss, and that this loss can be partially eliminated by washing the cable with a solvent soap solution and thoroughly rinsing in water.
3. The cleaning of the cable surface by scratch brushing only slightly lowers the corona loss below that which exists on a new cable properly washed.
4. The polishing of a cable surface by buffing temporarily decreases the loss on the cable below that which exists on a new cable properly washed.
5. Dragging a clean cable a distance of $^1/_2$ mile increases the loss on the cable above that which is found on a washed cable, but the loss is less for this condition than for the new, unwashed cable as received from the factory.
6. The surface of clean washed cables that have been subsequently dragged ages rapidly, so that with a year of weathering the loss is practically the same as found on a new, washed, undamaged cable.

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[9] Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

[10] Department of Water & Power, City of Los Angeles, Calif.

[11] Stanford University, Calif.

7. The surface produced by buffing ages rapidly, and as observed over one week's time showed a great variation in loss which was not regular but at times approached the loss value as found for the new, washed cable.

8. The variation in corona loss as found on new, washed cables shows that the voltage shift for the same power loss on cables of different sizes is practically proportional to $r \log S/r$, which is the factor in $E_0$ which is varied by dimensions. ($E_0$ is the disruptive voltage, $r$ the radius of the conductor, and $S$ the spacing.)

9. Insulator loss if not considered may introduce an appreciable error in corona loss measurements at high voltages. The loss can be partially eliminated by properly shielding the insulator strings.

10. A completely transposed line 1,050 ft. long showed the same corona loss as the same length of line untransposed. A horizontally spaced line showed a slightly higher loss than the same length of line with the equivalent triangular spacing.

In addition to the description and discussion of results of these tests, the paper includes a description of the modifications in the high voltage wattmeter for these measurements. (A.I.E.E. paper No. 32-113)

## The Triple-Harmonic Circuit in 3-Phase Power Systems

By
T. H. Morgan[12]
C. A. Bairos[11]
G. S. Kimball[11]

THE IMPORTANCE of triple-harmonic voltages and currents in electrical power systems is generally recognized by engineers associated with the power and telephone industries. It is desirable to have some convenient method of representation and calculation of the triple-frequency effects in 3-phase power systems.

The path of the third-harmonic current is different from that of the fundamental current and for this reason the circuit can be considered as separate and distinct. The characteristics of the triple-frequency circuit as determined by laboratory experiment are given in this paper, and methods of measurement of the required quantities for accurate solution of the triple-frequency circuit are described.

The results of an experimental investigation of the equivalent triple-frequency circuit as proposed by H. S. Osborne in 1915 are set forth. A typical simple 3-phase power network has been set up and the measured currents compared with computed values. Oscillograms are presented of voltages and currents with typical transformer connections demonstrating the principles of operation of the circuit both for normal and abnormal excitation conditions. The effects of various types of connected loads are discussed with particular attention to the condition of triple-frequency resonance. It is shown that triple-frequency resonance occurs when the external capacitive reactance of the circuit is equal to the triple-frequency no-load impedance of the transformer. Resonance produces large triple-frequency currents and serious distortion of the line-to-neutral voltage of the system. **(For presentation only; not scheduled for publication by the Institute.)**

## The Radio Plant of R.C.A. Communications, Inc.

By
H. H. Beverage[13]
C. W. Hansell[13]
H. O. Peterson[13]

THE Radio Corporation of America, through its subsidiary, R.C.A. Communications, Inc., operates a world-wide radio communication network between the United States and some 40 foreign countries. The major terminals of this world system are located at New York and San Francisco, with smaller centers at Honolulu, Manila, and Havana. The associated receiving and transmitting stations are located outside of these cities at various convenient distances.

A system has been worked out whereby all operations are concentrated in a central office at each of these terminals, thereby eliminating delays and errors inherent in the previous system of sending traffic over telegraph wires between the central office and the radio station. The development of short wave transmission also has greatly facilitated transoceanic radio service. Due to the great number of stations operating on both long and short waves, it is necessary to maintain means for monitoring the transmitters and for measuring the radiated frequencies with great accuracy. On the short waves, the frequency must be maintained within 0.05 per cent for old equipment and within 0.02 per cent for new equipment.

Starting with 6 circuits in 1920, these have expanded to a total of 54 circuits in 1932. During this period the number of messages also has increased greatly. Equipment necessary for this service of transmitting telegraph signals by modulation of radio frequency power is described in detail in this paper. Central office equipment, transmitting equipment for both long waves and short waves, receiving equipment, and frequency measurements are covered. (A.I.E.E. paper No. 32-115)

## Radiotelephone Experiments Over Short Distances

By
C. H. McLean[14]

RADIO in communication practise generally is associated with long distances over which physical plant is economically impossible. There are very few communities of appreciable size on the North American continent that are not linked up with the various telephone networks. Exceptions are to be found in British Columbia and Alaska where the territory intervening between the isolated settlements and populated areas is of such rugged nature as to render impossible from the standpoint of economy, the use of the usual telephone facilities.

Radio already successful over longer distance was adopted as the medium for providing telephone communication to the telephonically isolated centers lying within 600 miles north of Vancouver, B. C.

Radio experimental work on frequencies between 1,500 and 6,000 kc. has been in progress during the last 3 years employing equipment primarily designed for air transport communication. The radio transmitter has an unmodulated carrier rating of 400 watts, employs quartz crystal control of frequency and is capable of complete modulation. The receiver is of special design and includes the important feature of automatic gain control.

In the early experimental work a boat completely equipped with the necessary power plant and 400-watt equipment, cruised up the coast as far as southern Alaska, and tests were conducted between the boat and a land station located at Lulu Island near Vancouver. Considerable data relative to field strengths, fading and skip effect of various frequencies were collected for various points within a radius of 600 miles from the shore station. Further work included additional experimental installations at Campbell River, Ocean Falls, and Prince Rupert. Campbell River, the most northerly point connected by telephone lines, is the connecting point for the Ocean Falls (210 miles) and Prince Rupert (400 miles) radio links. Commercial operation over the last $1^1/_2$ years has proved the practicability of this form of communication, and it is believed that with the improved equipment now available, the expansion of this service upon a more permanent basis is justified. (A.I.E.E. paper No. 32-114)

PLEASE GIVE PAPER NUMBER when requesting pamphlet copies of Institute papers; when the publication number is not given requests cannot be filled.

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[12] Worcester Polytechnic Institute, Worcester, Mass.

[13] R.C.A. Communications, Inc., New York, N. Y.

[14] British Columbia Telephone Company, Vancouver, B. C.

# Middle Eastern District to Meet at Baltimore

THE next meeting of the Middle Eastern District will be held at Baltimore, Md., October 10–14, 1932, with headquarters in the Lord Baltimore Hotel. A preview of the attractions which the Baltimore meeting will offer is given by A. L. Penniman, Jr., of the Baltimore Section as follows:

"The technical program will be of unusual interest, including a joint session with the committee on insulation of the National Research Council at which papers will be presented covering the latest discoveries in dielectrics and the most recent developments of cable research. There will be papers on telephone cable covering the recent advances in the design and manufacture of pulp [illegible]ed cable, as well as on the use of cable [illegible]ephone distribution purposes, which [illegible] be supplemented by inspecting the [illegible] Breeze works of the Western Electric [illegible]any, a modern telephone cable manu[illegible]ring plant. The electric power session will be of particular interest as it will cover the economic aspects of water power, the design and construction of the Safe Harbor hydroelectric plant with particular reference to the hydraulic turbines which were especially designed for sustained efficiencies under variable head and at partial loads. There will be papers covering the 80-mile long, 230-kv. transmission line from Safe Harbor to Baltimore, the step-down station and the utilization of hydroelectric power in Baltimore with an inspection trip to the dam site where the Kaplan turbines, step-up station, transmission line river crossing and other interesting details may be inspected.

"Baltimore has much to offer visitors, not only in the development of industry but in the cultivation of art, literature, science, and engineering. In a little more than 2 centuries she has become one of the greatest manufacturing ports along our eastern seaboard but still retains the charm and culture which, with the aid of an ideal climate, developed from the inception of the province and produced such literary geniuses as Edgar Allen Poe, Sidney Lanier, Francis Scott Key, and James Ryder Randall of 'Maryland My Maryland' fame.

"The same courage and foresight which prompted Maryland to be the only one of the original 13 states to go through nearly the entire period of the Revolution as a separate and distinct sovereignty, then give to the federal government the territory now the District of Columbia and have its general assembly at Annapolis provide the necessary money for the completion of the federal buildings so that Congress might have a meeting place in the federal capital, also prompted the formation of the first gas-light company in 1816, and some 12 years later the starting of the first steam railroad in America and thereby laid the foundation of the fortune which was some half-century later to furnish the funds for the Johns Hopkins University, making possible incalculable contributions to science by such men as Rowland, Remsen, and Wood, and providing a fertile field for the rapid growth of the engineering school during its 20 years of existence under the able guidance of Whitehead and Kouwenhoven. Peale's Museum where the first gas lighting was installed and the Mt. Clare station from which the Baltimore and Ohio Railroad dispatched its first train and which on that historic day in May nearly 90 years ago received the first telegraphic communication in the world are both places of more than usual interest, as are the Flag House, where Mary Pickersgill made the American flag which waving over Fort McHenry inspired Key to write our national anthem, and the home of Charles Carroll, signer of the Declaration of Independence, which, splendidly preserved, is now a part of the Hopkins building group.

"A sightseeing trip and tea for the ladies will take them to Annapolis, the capital of the State for nearly 300 years, where General Washington surrendered his commission as commander-in-chief of the Continental Army, still retains the delightful atmosphere of colonial days. The old senate room has been preserved as it was when the continental congress met there while Annapolis was the nation's capital. King William's School founded in 1696, now St. John's College, is the third oldest institution of learning in the country, and was one of the first free schools in the colonies. Here is located the United States Naval Academy, in the crypt of whose chapel lies the remains of John Paul Jones, and here also is the flag which has given the Navy its watchword, 'Don't give up the ship.'

"The Baltimore Section urges you to come to the meeting in October with the assurance that you will find an unbounded hospitality."

**One of the many points of interest which may be visited during the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., October 10–13, 1932, is shown above. It is Mt. Vernon Place, looking north, and contains the first monument erected to the memory of George Washington. It was a gift from the French Republic**

# Last Call for the Pacific Coast Convention

INTEREST now is centered upon the next major event of the Institute's program; namely, the Pacific Coast convention to be held this year at Vancouver, B. C., August 30 to September 2, 1932. Details of this convention were published in ELECTRICAL ENGINEERING for July 1932, p. 518–9, and abstracts of all technical papers which at the time of publication of this issue were definitely scheduled, are given in this issue, p. 583–6.

Combined with the unusual entertainment features available in the region in such abundance and variety as to appeal to the "vacation" ideas of every man, woman, and child, the technical program and more formal features of the convention should attract a large registration.

### CHANGES MADE IN FEES FOR REGISTRATION AND ENTERTAINMENT

Of no little interest to those planning to attend the convention are the changes which have been made in fees. There will be no registration fee for the convention. Entertainment tickets, however, which cover the dance after the president's reception on August 30, the boat trip on August 31, the dinner on the boat, the banquet on September 1, and, in the case of the women, the bridge tea on September 2, will be available at the following rates:

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|---|---|
| Members and men guests | $6.00 per strip |
| Women | 5.00 per strip |
| Students | 2.50 per strip |

Tickets for separate items will be available for men, women, and students.

This new information regarding fees supersedes that given in ELECTRICAL ENGINEERING for July 1932, p. 518.

### EXCHANGE RATES FAVOR UNITED STATES CURRENCY

Consideration should be given by all persons from the United States attending the convention to the present rate of exchange between United States and Canadian currency. Persons from the United States may effect a net reduction of 15 per cent in the effective amount of expenditures on the Canadian side of the border by making an exchange from United States into Canadian currency at an established banking institution covering expenditures which will likely be made in Canada. United States money presented in Canada for payment of bills is accepted dollar for dollar without reference to the exchange rate which now favors United States credit.

# A.I.E.E. Directors Meet During Cleveland Convention

The regular meeting of the board of directors of the American Institute of Electrical Engineers was held at the Hotel Cleveland, Cleveland, Ohio, on Wednesday, June 22, 1932, during the annual summer convention of the Institute.

Present were: *President*—C. E. Skinner, East Pittsburgh, Pa. *Past-president*—W. S. Lee, Charlotte, N. C. *Vice-presidents*—H. V. Carpenter, Pullman, Wash.; H. P. Charlesworth, New York, N. Y.; L. B. Chubbuck, Hamilton, Ont.; W. E. Freeman, Lexington, Ky.; W. B. Kouwenhoven, Baltimore, Md.; T. N. Lacy, Detroit, Mich.; I. E. Moultrop, Boston, Mass.; G. C. Shaad, Lawrence, Kans. *Directors*—A. E. Bettis, Kansas City, Mo.; A. B. Cooper, Toronto, Ont.; B. D. Hull, Dallas, Tex.; J. Allen Johnson, Buffalo, N. Y.; A. E. Knowlton, New York, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New York, N. Y. *National treasurer*—W. I. Slichter, New York, N. Y. *Acting national secretary*—H. H. Henline, New York, N. Y.

Present by invitation were: *Past-presidents*—Paul M. Lincoln, Ithaca, N. Y.; Charles F. Scott, New Haven, Conn. *Officers-elect*—K. A. Auty, Chicago, Ill.; G. A. Kositzky, Cleveland, Ohio; A. H. Lovell, Ann Arbor, Mich.; E. B. Meyer, Newark, N. J.; A. C. Stevens, Schenectady, N. Y.

The minutes of the directors' meeting of May 20, 1932, were approved.

A report of a meeting of the board of examiners held June 15, 1932, was presented and approved. Upon the recommendation of that board, the following actions were taken upon pending applications: 3 applicants were transferred to the grade of Fellow; 7 applicants were elected to the grade of Member and 30 were transferred to the grade of Member; 62 Associates were elected; 54 Students were enrolled.

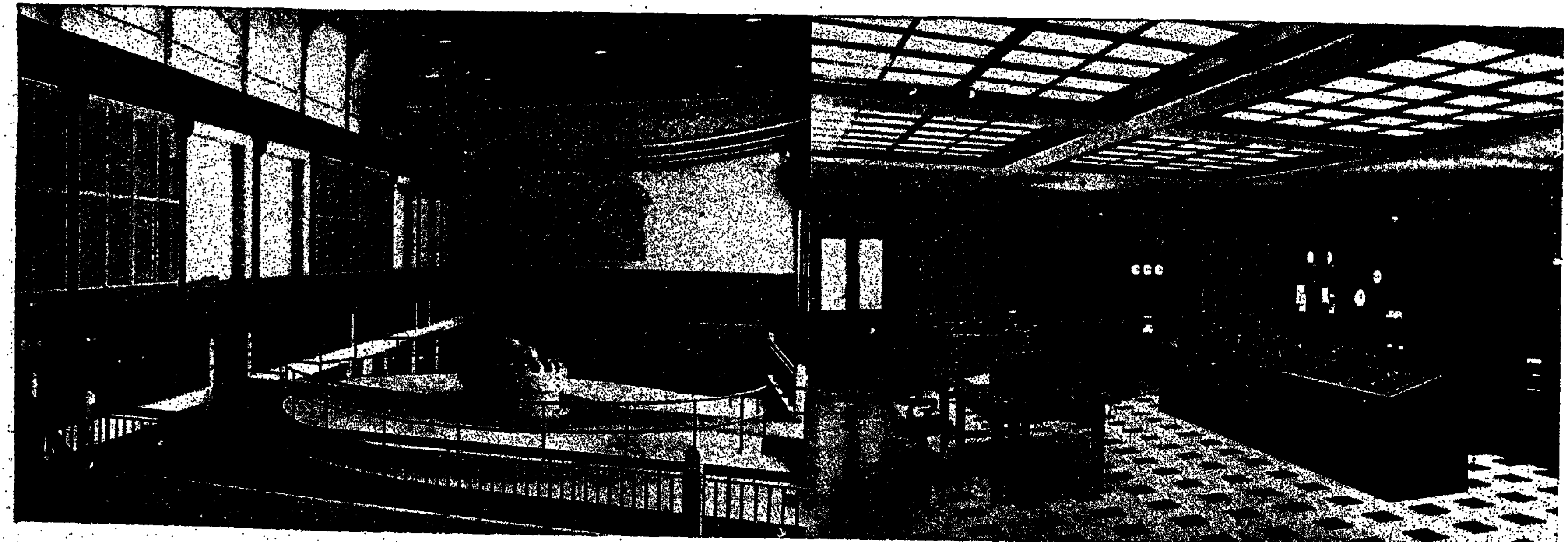
Approval by the finance committee, for payment of monthly bills amounting to $42,808.20, was ratified.

For the purpose of stimulating more prompt payment of membership dues by the mailing of dues notices at shorter intervals, after May 1, 1933, Section 18 of the By-Laws was amended by replacing the second and third sentences with the following: "On August first, November first, and February first, notices shall be sent to those remaining in arrears, the February first notice to be accompanied by a copy of this section of the By-Laws."

Resolutions were adopted, expressing the directors' appreciation of the services of the Cleveland convention committee and its subcommittees.

Various recommendations adopted at the conference of officers, delegates, and members on June 20 and 21 were considered and referred to appropriate committees already in existence or to be appointed; and approval was given to a recommendation that the Districts be requested, when planning Districts meetings, to consider the formation in each case of a subcommittee of the general convention committee to coordinate all phases of student participation in the convention activities, and to schedule a student session which will not conflict with any of the technical sessions, inspection trips, or other events of the convention; or in lieu thereof, to consider scheduling one or more student papers in the programs of the main technical sessions.

Other matters were discussed, reference to which may be found in this or future issues of ELECTRICAL ENGINEERING.



Generator room (left) and control room (right) in the Ruskin power plant of the British Columbia Power Corporation, Ltd., near Vancouver, B. C. Inspection of this plant will be made during the A.I.E.E. Pacific Coast convention, August 30–September 2, 1932. The generator, rated at 47,000 hp., is of the "umbrella" type

## Convention Sports Trophy Information Completed

Supplementary information and a correction are presented here to bring correctly up to date the listing of winners of A.I.E.E. summer convention sports trophies given on p. 521 of ELECTRICAL ENGINEERING for July 1932. The name of L. F. Deming (A'11) of Philadelphia, Pa., permanent winner of the first Mershon golf trophy was misspelled in last month's report.

Concerning the Mershon tennis trophy it should be recorded that the first trophy was offered for competition at the 1923 summer convention held at Swampscott, Mass., and was won in that year by J. P. Nikonow (M'18) of New York, N. Y. In 1925 the cup was won permanently by G. A. Sawin (M'13) East Pittsburgh, Pa., who also had won the tennis tournament of 1924. In 1926 Past-President Ralph D. Mershon made available a second tennis trophy which was won in that year by L. B. Chubbuck (M'26) of Hamilton, Ontario, Canada.

These additional data together with a correction in the present address of Mr. A. J. Gowan make the following list of Mershon tennis trophy winners correct according to present Institute records:

**First Trophy**

1923—J. P. Nikonow, New York, N. Y.
1924—G. A. Sawin, East Pittsburgh, Pa.
1925—G. A. Sawin, East Pittsburgh, Pa.

**Second Trophy**

1926—L. B. Chubbuck, Hamilton, Ontario, Canada.
1927—G. A. Sawin (M'13) East Pittsburgh, Pa.
1928—P. H. Hatch (M'29) Stamford, Conn.
1929—A. J. Gowan (A'23) Rock Island, Ill.
1930—E. F. Lopez (M'18) Mexico City, Mex.
1931—J. K. Peck (A'27) New York, N. Y.
1932—R. A. Monroe (A'30) Pittsburgh, Pa.

## American Tentative Standard for Engineering Abbreviations Adopted

BRINGING to a close a preliminary period of several years of effort, the sectional committee on scientific and engineering symbols and abbreviations of the American Standards Association recently made a final report to that Association embracing an American Tentative Standard specifying and governing the use of abbreviations for scientific and engineering terms. This tentative standard is strictly an editorial specification listing more than 200 abbreviations considered as acceptable for use in the preparation of technical manuscripts, and setting forth 8 practical rules governing the use of such abbreviations in text matter. In this initial list of abbreviations the committee has included only the terms in most common use.

The tentative standard as it now stands, with its list of abbreviations and its rules governing their use, has been accorded official approval by the A.I.E.E. and also by the American Association for the Advancement of Science, the American Society of Civil Engineers, the Society for the Promotion of Engineering Education, and The American Society of Mechanical Engineers. It is expected that these sponsoring organizations will bring into conformity with the standard list the abbreviations now used in their respective publications, and from time to time will contribute to the extension of the standard list by the addition of further mutually agreeable abbreviations. In sanctioning these abbreviations, each society authorized those falling within the sphere of its professional activity, recognizing at the same time the other abbreviations as authorized by the other organizations. Controversial abbreviations were omitted from the list subject to subsequent settlement.

The subcommittee of the sectional committee that carried on the research in abbreviations for scientific and engineering terms includes G. F. Bateman, professor of mechanical engineering, Cooper Union, New York, N. Y.; S. McK. Gray, Electrical Testing Laboratories, New York, N. Y.; W. T. Magruder, professor of mechanical engineering, The Ohio State University, Columbus, Ohio; Dr. W. N. P. Reed, assistant editor, Engineering and Mining Journal, McGraw-Hill Publishing Company, Inc., New York, N. Y.; H. E. Ruggles, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.; working under the chairmanship of G. A. Stetson, editor, The American Society of Mechanical Engineers, New York, N. Y. Officers of the A.S.A. sectional committee on scientific and engineering symbols and abbreviations include J. F. Meyer, Bureau of Standards, Washington, D. C., chairman; S. A. Moss, General Electric Company, West Lynn, Mass., vice-chairman; P. S. Millar, Electrical Testing Laboratories, New York, N. Y., secretary; and S. McK. Gray, assistant secretary. The executive committee of the A.S.A. sectional committee includes J. F. Meyer as chairman and S. A. Moss as vice-chairman; also Dr. A. E. Kennelly, Harvard University, Cambridge, Mass., representing the American Association for the Advancement of Science; H. N. Davis, Stevens Institute of Technology, Hoboken, N. J., representing The American Society of Mechanical Engineers; and C. M. Spofford, Boston, Mass., representing the American Society of Civil Engineers.

### RULES GIVEN

To clarify a necessary distinction, the committee has ruled that:

A symbol is a letter or sign used in a formula as a substitute for any numerical value. A shortened expression for a name or a unit is an abbreviation and *not* a symbol. Concerning the use of abbreviations, the committee's recommended standard specifies that:

1. Abbreviations should be used sparingly in text and with regard to the context and to the training of the reader. Terms denoting units of measurement should be abbreviated in the text only when preceded by the amounts indicated in numerals; thus "several inches," "one inch," "12 in." In tabular matter, specifications, maps, drawings, and texts for special purposes, the use of abbreviations should be governed only by the desirability of conserving space.

2. A sentence should not begin with a numeral followed by an abbreviation.

3. Short words such as ton, day, and mile should be spelled out.

4. Abbreviations should not be used where the meaning will not be clear. In case of doubt, spell out.

5. The use of conventional signs for abbreviations in text is not recommended; thus "per," not /; "lb." not #; "in.," not." Such signs may be used sparingly in tables and similar places for conserving space.

6. The committee indorses the movement which was begun by the international committee on weights and measures in omitting the period in abbreviations of metric units and further indorses the growing tendency toward the omission in abbreviations of other origin. In the interests of economy and the reduction of waste, the elimination of the period is recommended except where such an omission results in an English word. Exceptions to this practise will be found in a few mathematical and chemical terms, such as sin, tan, log, As, etc.

7. The letters of such abbreviations as A.I.E.E. should not be spaced (not A. I. E. E.).

8. The use in text of exponents for the abbreviations of square and cube and of the negative exponents for terms involving "per" is not recommended. The superior figures usually are not available on the keyboards of typesetting and linotype machines, and composition therefore is delayed; also there is the likelihood of confusion with footnote reference numbers. These shorter forms are permissible in tables and sometimes are difficult to avoid in text.

Principal changes that may be noted in the tentative standard list of abbreviations include the elimination of practically all periods from abbreviations, and shorter forms of some otherwise common abbreviations. As new material is set up for subsequent publication in ELECTRICAL ENGINEERING and other A.I.E.E. publications, such abbreviations as are used will be brought into conformity with the tentative standard list.

### PERMISSIBLE ABBREVIATIONS

In conformity with the A.S.A. tentative standard, the following partial list indicates the style of abbreviations recommended by the A.I.E.E. publication committee for use in Institute manuscripts and publications:

| | |
|---|---|
| Acre-foot | acre-ft |
| Alternating-current (as adjective only) | a-c |
| Ampere | amp |
| Ampere-hour | amp-hr |
| Antilogarithm | antilog |
| Average | avg |
| Barrel | bbl |
| Baumé | Bé |
| British thermal unit | Btu |
| Calory | cal |
| Candlepower | cp |
| Centigram | cg |
| Centimeter | cm |
| Circular mils | cir mils |
| Circular-mil (adjective) | cir-mil |
| Cologarithm | colog |
| Cord | cd |
| Cosecant | csc |
| Cosine | cos |
| Cotangent | ctn |
| Coulomb | spell out |
| Counter electromotive force | counter emf |
| Cubic | cu |
| Cubic feet per second | cfs |
| Current density | spell out |
| Day | spell out |
| Decibel | db |

| | |
|---|---|
| Degree | deg |
| Degree (angular measure) | ° |
| Degree Centigrade | deg C |
| Degree Fahrenheit | deg F |
| Diameter | diam |
| Direct-current (as adjective only) | d-c |
| Efficiency | eff |
| Electric | elec |
| Electromotive force | emf |
| Elevation | el |
| Engine | eng |
| Engineer | engr |
| Engineering | engg |
| Equation | eq |
| Farad | spell out |
| Foot | ft |
| Foot-candle | ft-c |
| Foot-pound | ft-lb |
| Gallon | gal |
| Gallons per minute | gpm |
| Gallons per second | gps |
| Grain | spell out |
| Gram | g |
| Gram-calory | g-cal |
| Henry | h |
| Horsepower | hp |
| Horsepower-hour | hp-hr |
| Hour | hr |
| Hyperbolic sine | sinh |
| Hyperbolic cosine | cosh |
| Hyperbolic tangent | tanh |
| Inch | in. |
| Joule | j |
| Kilocycle | kc |
| Kilogram | kg |
| Kilometer | km |
| Kilovolt | kv |
| Kilovolt-ampere | kva |
| Kilowatt | kw |
| Kilowatthour | kwhr |
| Lambert | L |
| Logarithm (common) | log |
| Logarithm (natural) | $\log_e$ |
| Lumen | l |
| Lumen-hour | l-hr |
| Lumens per watt | lpw |
| Magnetomotive force | mmf |
| Mass | spell out |
| Megohm | spell out |
| Meter | m |
| Mho | spell out |
| Microampere | μa |
| Microfarad | μf |
| Micromicron | μμ |
| Micron | μ |
| Microwatt | μw |
| Mile | spell out |
| Miles per hour | mph |
| Milliampere | ma |
| Millifarad | mf |
| Milligram | mg |
| Millihenry | mh |
| Millilambert | mL |
| Milliliter | ml |
| Milimeter | mm |
| Millimicron | mμ |
| Million | spell out |
| Millivolt | mv |
| Minute | min |
| Minute (angular measure) | ′ |
| Month | spell out |
| Ohm | spell out |
| Ohm-centimeter | ohm-cm |
| Ounce | oz |
| Potential | spell out |
| Potential difference | spell out |
| Pound | lb |
| Pound-foot | lb-ft |
| Power factor | spell out |
| Radian | spell out |
| Reactive kilovolt-ampere | rkva |
| Reactive volt-ampere | rva |
| Revolutions per minute | rpm |
| Revolutions per second | rps |
| Root mean square | rms |
| Secant | sec |
| Second | sec |
| Second (angular measure) | ″ |
| Second-foot | (see cubic feet per second) |
| Sine | sin |
| Square foot | sq ft |
| Square root of mean square | rms |
| Tangent | tan |
| Ton | spell out |
| Ton-mile | spell out |
| Versed sine | vers |
| Volt | v |
| Volt-ampere | va |
| Volt-coulomb | spell out |
| Watthour | whr |
| Watts per candle | wpc |
| Week | spell out |
| Yard | yd |
| Year | yr |

# Summarized Review of Some Cleveland Convention Discussions

PRINCIPAL discussions of the Cleveland convention papers are summarized herewith. The papers to which these discussions refer were abstracted in ELECTRICAL ENGINEERING for June 1932, p. 405–13.

Only discussion submitted in writing in accordance with governing A.I.E.E. rules is summarized. Complete discussion, together with all approved papers, will be published in the TRANSACTIONS.

### THE ENGINEERING SUBJECTS IN THE COLLEGE PROGRAM

S. M. Dean (Detroit, Mich.) discussed this subject with the view that an increasingly large proportion of engineers eventually get into administrative positions. He agrees, however, than any electrical engineer must have a basic training in the fundamental concepts. Referring to Table I of the paper, he would include in the first prescribed group the fundamental courses as well as transmission and distribution; also electronics. He also suggested that a rather wide range of the more specialized subjects should be offered as electives to determine the "natural bent" of the student and to show him into what the various branches of the electrical engineering profession will lead him. The necessity for a successful administrative engineer to take a broad view of any situation, and his ability to set forth his ideas in a logical and convincing manner, were emphasized as important characteristics. He suggested, too, that the story of obstacles surmounted and of the men who contributed to this successful development of the various steps both from a strictly engineering angle as well as from the commercial point of view, would serve as a helpful background.

R. E. Hellmund (East Pittsburgh, Pa.) called attention to the lack of training in the mechanical features of machine design and engineering materials as shown in Table II of the paper. He stressed the point that all component parts of electrical machines and apparatus present mechanical problems and that the greater part of the work of electrical design engineers has to do with the mechanical phase. He believes that some of the time now devoted to heat, power, and hydraulics should be devoted to mechanical design and engineering materials; at least, he believes good courses on these subjects should be available to those wishing to go into design work.

A. E. Knowlton (New York, N. Y.) in his discussion of this subject urged generous support of Dean Lovell's plea that the electrotechnical content of the curricula be surveyed, but at the same time he warned against placing too much emphasis on statistical data. With regard to reversion to fundamentals and the elimination of specialization, two solutions were offered. One of these suggested a review of the content of fundamentals with a test of every item for its broad applicability over the whole range of energy magnitudes and diversified applications; those phenomena and principles having the widest range of adaptability to electrical activities would appear most entitled to be ranked as fundamentals. The other solution suggested that more stress be placed upon functional significance of electrical phenomena and the physical equipment devised to exploit them. The "horizontal" character of such a set-up would give the subject matter a bearing upon every branch of the art involving an exercise of those functions.

Another discussion by D. C. Jackson, Jr. (Lawrence, Kansas) brought out recent changes made in the electrical engineering curricula of both the University of Kansas and Kansas State College. The former now has a greater number of hours given over to fundamental course in electrical engineering, while the latter has increased the number of hours for electronics, making it a required rather than an elective course. These changes tend to substantiate the trend indicated by Professor Lovell in his paper.

Another view of this subject from the point of industry was presented by W. W. Lewis (Schenectady, N. Y.), who explained that graduates ultimately were absorbed through 3 main channels: large manufacturing companies; large public utilities; and small manufacturing companies, public utilities, and industrial plants. The first 2 groups maintain more or less extensive training courses and require broad training in fundamentals; but the latter group requires in addition specialized training to fit the graduate for immediate usefulness. Since very few students know until just before graduation in which group they will be employed, Mr. Lewis believes that it is obviously necessary to give all students the broad fundamental courses plus a number of specialized courses. He agrees that the subject of electronics is becoming increasingly important and that practically all of the courses listed in Tables I and II of the paper were desirable, with the exception of those on surveying and foreign languages.

Still another view from industry was contributed by L. F. Morehouse (New York, N. Y.). He questioned whether all of the required work should not be given in truly fundamental courses in which the broad fundamentals would be illustrated from every phase of electrical engineering. If this should be impractical it was suggested that required courses other than those designated as "fundamental" should have a more general content and be more widely illustrative of modern electrical engineering in its broadest application.

L. W. W. Morrow (New York, N. Y.) ably discussed the subject of technical education, calling attention to the need for engineering courses to keep abreast of the rapidly changing art. An analysis of Table I of the paper quickly raised a number of pertinent questions which indicated the variation in hours devoted to fundamental courses, the lack of correlation between fundamental course hours and additional required or elective hours, the specialized courses consistently taught, and the lack of courses such as electrochemistry and electronics. Upon analysis, such data showed very vividly an antiquated, superficial, and cumbersome content for the technical engineering courses. The next step in this discussion, based upon Mr. Morrow's broad experience and extensive contacts, showed briefly but valuably what problems confront practising engineers of today. In conclusion, the following recommendations were made relative to the technical content of college courses: (1) Stick to theoretical principles and apply them to all current engineering applications; (2) eliminate the old, the standardized, and the obsolete principles and applications, and replace them with new and live theories and applications; and (3) do not specialize in terms of arbitrary and artificial field divisions of engineering, but require all students to take the same fundamental course with a few electives in specialized theory instead of practise.

A. E. Silver (New York, N. Y.) also discussed this subject, and was of the opinion that natural ability justifying a 4-year course should be devoted primarily to the laying of a foundation—learning the principles of accomplishment by effectively directing the forces at hand, acquiring the trait of making one's knowledge available and of value to others, and finding one's natural self—leaving specifications largely to graduate work and one's later initiative and experience.

### Educational Aspects of Engineering and Management

R. E. Hellmund (East Pittsburgh, Pa.) discussed this subject and emphasized particularly the point that enthusiasm over the fact that engineering education had turned out personnel suitable for industrial management, should in no way lead to a diminution of the technical engineering phase of the undergraduate program. It was pointed out that although only 25 per cent remain in technical work after the age of 40, the majority soon after leaving college are called upon to carry on technical engineering. He advocated that rather than change the undergraduate courses, managerial training should be given in the various postgraduate programs.

D. C. Jackson, Jr. (Lawrence, Kan.) also discussed this phase of the subject and it was his belief that engineering training would continue to be valuable for managerial duties in industries based upon engineering. With students, there might be a trend toward business courses, administration or management, but it appeared doubtful whether such courses of study could provide so satisfactory a training as do engineering courses.

Another discusser, E. E. Johnson (Schenectady, N. Y.), related a number of instances where men who have demonstrated a high order of technical leadership gradually came into positions of technical management. He did not feel that inclusion of a fundamental technical background in engineering curricula would detract from the field of management.

### Reliability and Economy in the Operation of Large Electric Systems

This subject was introduced very comprehensively by the presiding officer, F. H. Hollister (Chicago, Ill.), who told of the origin and objective of the symposium. He pointed out that each district had its own peculiar problems and that there were scarcely 2 alike. For example, Philadelphia with a major hydroelectric connection was contrasted to Chicago with no hydroelectric connection of any great importance. Each paper was believed to present a method of determining how each of the respective metropolitan systems with its particular characteristics is operated to secure maximum reliability and economy. In each instance, however, the goal is reached in a different manner by devious paths that rarely cross but it is believed that each system with its scheme of operation has ample backing and justification.

One of the interesting phases of a discussion by R. L. Thomas (Baltimore, Md.) related to the essentiality of accurately forecasting future loads under present economic conditions. It is his belief that under present conditions, any forecaster who predicts loads for even a year or 2 in advance, with an error of only 2 or 3 per cent, may consider himself fortunate.

J. R. Baker (Baltimore, Md.) in his discussion summarized indications in the papers which related to interconnections. Apparently they were not producing the widely connected geographical power scheme forecast by some of the early proponents. The true function of interconnection seemed to be of a supplementary nature, and the papers tended to show that the main reliance for power supply in any load area would continue to reside in power stations adjacent to the load.

Another discussion by C. M. Gilt (Brooklyn, N. Y.) considered 2 different methods of meeting the situation arising when it might become necessary to shut down a generating station completely. Costs for such systems at first might appear high, however, for the larger systems, the magnitude of such completely isolated stations is of the order of 500,000 kva., and makes use of the most economical size of units available.

Another part of a general discussion presented by J. R. Baker (Baltimore, Md.) referred to carrying out construction projects in advance of load requirements for reasons of reliability or economy in operation. He explained that such work had been confined chiefly to the replacement of obsolete and inadequate equipment. In general, for reasons of economy in operation the company was not committed to investments in advance of actual load requirements. The exception is in the case of such items as converting attended substations into the automatic type where definite labor savings can be predicted.

### The Coordination of Transformer Insulation With Line Insulation

R. N. Conwell (Newark, N. J.) cited objections to the fixing of transformer insulation at a definite arbitrary value and then relying upon the designer of a transmission line to coordinate with these values. Such a method, he explained, surely could not produce a well-balanced, satisfactory, economical, system design. The transmission designer is handicapped at the very

## The Engineer

HE IS THE master of the Laws of Nature. On a sound foundation of mathematics, science, and economics, he bends the materials and forces of Nature to his plan and rears the structure of civilization.

With vision, resourcefulness, and ingenuity, he labors to increase the comfort, wealth, and safety of his fellowmen.

He attacks his problems with the vision of the pioneer, the integrity of the scientist, the accuracy of the mathematician, the practicality of the business man, the resourcefulness of the inventor, and the courage of the conqueror.

He is the planner and builder. He builds his visions into enduring realities.

He is the pathfinder of civilization. He breaks down the barriers, bridges chasms, establishes communication, and straightens the way for commerce and human progress.

He is the protagonist of efficiency. He reduces the effort, eliminates waste, and increases production.

He is the creator of a Nation's wealth. He drains the swamps, reclaims the deserts, develops resources, and harnesses power. He builds the machinery of industry, the wheels of commerce, and the structure of business.

He is the great coordinator. He plans and directs the construction of projects representing the investment of millions of dollars and the labor of thousands of men.

He investigates with open mind, and gets the facts before he makes decisions. He plans with thoroughness and builds with fidelity.

To his rich heritage from the labors of past generations of engineers and scientists, he adds his contributions. He continues the work of forcing outward the challenging barriers that separate Man's efforts from the impossible.

By D. B. Steinman, President of the New York State Society of Professional Engineers, and Past-President of the American Association of Engineers. Reprinted from "The American Engineer" for February 1932.

start by the necessity of meeting limits established without regard to service conditions or local factors, such as the character of the terrain, lightning exposure, frequency of storms, or the position of the line with regard to storm paths. He suggests that a suitable committee canvass thoroughly a large number of operating companies to determine preferences in future insulation levels, and he believes that the methods employed for coordination should be the basis of determining transformer insulation requirements.

F. J. Vogel (Sharon, Pa.) also discussed this subject; it is his belief that the coordination of transformer insulation with the gap was of great value not only to operating engineers but to the manufacturers in providing a yardstick to measure the surge strength of station apparatus. He felt that the gap would be used merely as the level in the case of very low voltages, and that for this purpose, the table in the paper might be extended.

J. B. Hodtum (Pittsburgh, Pa.) discussed justification for the development of the coordinated distribution transformer. He explained that such a transformer had been developed and had been on the market now for 4 years. Impulse tests confirmed by 4 years of service have demonstrated that these transformers would flash over the bushings before the transformer itself would fail. Over 5,000 such transformers have been in service without a single failure having been reported.

Another discussion of this subject by J. K. Hodnette (Sharon, Pa.) pointed out that if the transformers were designed in the usual way with the high-voltage winding divided into 2 or more parts, the initial voltage stresses across the coils would be reduced materially as compared with the coordinated design. From this material reduction in stress it would appear that the shields were not essential for building a transformer with coordinated insulation.

### CHARACTERISTICS OF SURGE GENERATORS

C. L. Fortescue (East Pittsburgh, Pa.) discussed this subject and explained that the importance of the paper rested in the fact that the author had demonstrated that what might appear as extremely complicated circuits, could be represented with a close approximation by simple circuits. He believes that the author has shown the ease of predicting the actual wave under test conditions, thus permitting specifications for surge testing of apparatus without fear, provided surge measurements are properly carried out and calculations are made beforehand, to insure that the apparatus is receiving the proper test.

W. L. Lloyd, Jr. (Pittsfield, Mass.) believes this paper timely, well-written, and interesting, but he does not feel that the subject is particularly new. Reference was made to Mr. Peek's first lightning generator of 1913, and to the fact that the impulse voltages delivered by such a circuit have been subject to calculations.

### LOAD RATIO CONTROL CIRCUITS

F. L. Snyder (Sharon, Pa.) in his discussion of this subject pointed out that whether an air-gap should or should not be used in the core of the reactor depended upon the characteristics of the circuit desired. In any event he felt that the tap changer, the transformer, and the reactor must be insulated for the voltages which may be impressed upon them under both normal or abnormal conditions. Conceivably, a tap changing operation might take place at the instant of line short circuit.

A. Boyajian (Pittsfield, Mass.) in discussing this subject felt that usually attempts to limit voltage rise by saturation result in just the opposite effect. Noncritical expectations based on r.m.s. characteristics come to grief, and the very feature (saturation) depended upon for protection, stings and pierces the insulation of the circuit by needle-shaped voltage peaks. In terms of elementary sine wave concepts associated with linear circuits and without recourse to advanced mathematics, he analyzed the meaning of saturation phenomena in an a-c. circuit as understood physically.

H. O. Stephens (Pittsfield, Mass.) discussed this subject. He referred to tests which showed that when preventive reactors with closed magnetic circuits were used, decided peaks in the voltage waves across the reactors were obtained, the arcing on the contacts was severe, and the contact life unsatisfactory. However, with air core reactors, or with iron core reactors having suitable air-gaps in the core so as to obtain a substantially straight-line volt-ampere characteristic throughout the working range, the bad peaks in the voltage across the reactor were eliminated and the life of the contacts greatly increased.

### INFLUENCE OF BRUSH CONTACT DROP ON COMMUTATION

R. E. Hellmund (East Pittsburgh, Pa.) in discussion of this subject gave an interesting hypothesis of contact phenomena which, although not as yet checked with results of experimental data, seemed valid. It is his belief that contact phenomena may eventually be explained in a rather simple manner by assuming certain mechanical conditions in the contact areas, nothing but ohmic resistance in the materials proper, and other already well-known phenomena.

L. A. Heath (Long Island City, N. Y.) cited the existence of ever-changing conditions of contact between brush and commutator. He referred to brush sparking when a cold rotary or generator is started and immediately carries full load. During this initial period the slope of the brush contact curve indicates too great an interpole field strength, but after sparking ceases, the contact curve is quite normal. Inspection of the brush faces during this initial period indicates that the brushes have changed their seating from that taken at the last shut-down.

Another discussion by W. E. Stine (Cleveland, Ohio) explained that the authors' theory of sliding contact and data submitted was in very close conformity with a theory which the discusser advanced several years ago to explain brush contact drop characteristics. The authors were asked a number of questions about the physical properties and mechanical conditions in connection with their work and points with which the discusser was not in agreement were cited.

### SINGLE-PHASE SHORT-CIRCUIT TORQUES OF SYNCHRONOUS MACHINES

L. A. Kilgore (East Pittsburgh, Pa.) in his discussion of this subject felt that the authors had presented a relatively simple solution to the difficult problem of calculating the pulsating torque of single-phase short circuits. He explained that the extended 2-reaction theory and the constant interlinkage theorem were applied to include the effect of direct and quadrature axis damping circuits.

Another discussion of this subject by B. L. Robertson (Berkeley, Calif.) made reference to the previous work on synchronous machines by Doherty, Penny, and others. The assumptions of, and conditions set forth in previous work were compared with those in the present paper, the discusser also pointing out the continued use of the theorem of constant linkages.

### WIRE COMMUNICATION AIDS TO AIR TRANSPORTATION

H. T. Killingsworth (Cleveland, Ohio) in connection with this subject described the communication equipment of the Cleveland airport, which includes practically all of the features described in the paper. Five teletypewriter circuits radiate from Cleveland, paralleling the more important routes. The administration building which contains this equipment is connected to the long wave radio transmitting station, urgent messages being retransmitted to planes in flight by the use of the re-perforating equipment. Short wave radio equipment is used by the airport authorities in dispatching planes, both upon leaving and landing at the field.

### CHARACTERISTICS OF ELECTROMAGNETIC RADIATION FROM AIRCRAFT IN FLIGHT

The authors, J. C. Coe and T. C. Rives, were asked several questions concerning the possibility of obtaining effects similar to fading when flying rough, the factors upon which the distance free from fading depended, and comparisons between different types of antennas. It was explained that good flying conditions were encountered during these tests, and that variation in field strength would be due much more to the changes in orientation of the transmitting antenna with respect to the receiving antenna than to an actual change in altitude or distance. The attenuation undergone by earthbound rays was found to be independent of whether daylight or darkness obtained, and fading was encountered when the field strength became less than a certain value, this value depending upon frequency, time of day, etc. With regard to effects with the different types of antennas, it was explained that where distances are much greater than altitude, the trailing wire antenna would give a greater field strength; and as to the distance free from fading, this also would be favored by the trailing wire antenna rather than by the horizontal type.

### VERTICALLY CUT SOUND RECORDS

In connection with this subject Benjamin Olney (Rochester, N. Y.) discussed the practical limitations which prevent the radio broadcasting and receiving of high quality music as demonstrated by the authors. To obtain a high frequency range in radio reception comparable to that which was demonstrated, the following steps would be necessary aside from merely extending the frequency range of both the radio receiver and the broadcast system: (1) frequency spacing of adjacent broadcast channels must be doubled; (2) the effective power must be increased to provide a greater signal noise ratio; (3) carbon button microphones must be used with caution or eliminated; and (4) transmitter overmodulation must be avoided to a much greater extent than at present. Also space limitations in the home would constitute the principal limiting factor of low-frequency reproduction.

### Adequate Wiring of Buildings

Philip Sporn (New York, N. Y.) in his discussion of this subject felt that the engineering profession as a whole, and the membership of the Institute in particular, had not given sufficient attention to this subject. He hoped that the paper on this subject might serve as a prelude to others which might describe advances and new developments in this field. One of the important reasons for the lack of progress in this field was thought to be due to the general belief that the National Electric Code has a legal status, and that there is nothing engineers can do except comply with this code. He pointed out that the code has no legal status of any kind except that which is given to it by municipal or other ordinances, and such legislation might call for installations in direct contradiction to the code.

J. M. Bryant (Minneapolis, Minn.) also discussed this subject and felt that the Institute should cooperate with standardizing bodies in the adoption of new codes of wiring. An increase in the standards for wiring so that conductors in new structures would have sufficient capacity to permit increasing the illumination was recommended. He believes that there is no type of building which better illustrates the changing tendencies than do the public school and buildings in institutions of higher education. An actual experience was cited and served to illustrate this point.

F. C. Caldwell (Columbus, Ohio) in discussing this subject referred to a simple application of differential calculus which showed that the greatest economy of copper for a 2-wire system will be attained when the permitted voltage drop is divided between a feeder and its branches, in proportion to the length of the feeder and the average length of the branches. Similar relations for 3-wire feeders could be worked out with any given relation of neutral to outside wire. This simple principle he stated has never been observed in treatises on wiring.

Another discussion on this subject by L. W. W. Morrow (New York, N. Y.) brought out that there are 3 aspects of wiring and lighting that should receive serious consideration by every man in the industry. These are the humanitarian, business, and technical aspects. With regard to business possibilities, he pointed out that a 30-story office building offers a load in the neighborhood of 36,000 kw. High-grade engineering and detailed attention is devoted to a 500-kw. industrial power load; although the lighting load is infinitely the larger, it receives but little attention. Also, each home market if adequately sold and engineered offers from 10 to 15 kw. of load. He felt that no more fruitful field for engineering than this existed in the industry, and that it should have serious attention.

A discussion by Morgan Brooks (Urbana, Ill.) referred to means for revising inadequate house wiring without recourse to complete replacement. He also brought out that the predicted installation of air-conditioning apparatus in homes makes adequate wiring a debatable question. As a remedy, he stated that often where coffee urns, toasters, and chafing dishes affect dining room illumination adversely, a single additional circuit can be installed economically, connected to the opposite side of the distribution system. Also judicious reconnection of circuits at the cut-out cabinet may save the expense of rewiring.

Taylor Reed (Reedsville, Pa.) recommended that there should be a revised code on adequate wiring of buildings to set limits of permissible momentary dip of voltage.

Another discussion of this subject by P. L. Alger (Schenectady, N. Y.) suggested that the wiring code committee prepare a supplement to the standard code to explain the minimum character of standard code provisions and give detailed figures on the possible savings to be made by the use of larger wire sizes and more numerous outlets.

### Current Propagation in Electric Railway Propulsion Systems

K. L. Maurer (New York, N. Y.) discussed this subject and pointed out that the peculiar feature of the type of circuit treated in this paper, as distinguished from the ordinary power circuit, is that one side is made up of a concentrated metallic conductor in parallel with a distributed conductor, the earth. The effect of the earth as a conductor, upon the electrical constants, cannot be neglected as ordinarily it might be in the case of the usual power circuit.

### Application of High-Speed Relays

E. H. Bancker (Schenectady, N. Y.) in his discussion of this subject felt that papers of this type which presented results actually attained in operating practise, were valuable as they point out to designing and application engineers factors which have been overlooked or neglected. In this way such papers offer the opportunity for a further improvement in protective relaying. These remarks were illustrated by several cases taken from the paper and analyzed by the discusser.

### A New High-Speed Reactance Relay

In connection with this subject Philip Sporn (New York, N. Y.) stressed the fact pointed out in the paper, that in spite of the high cost, because of the need of high-voltage instrument potential transformers, any system of distance relaying gives high speed protection for only about 80 per cent of a line section. He then referred to the pilot scheme for universal protection and the objections to using a separate set of pilot wires. As a solution to this difficulty, recourse was taken to the use of carrier current and tests which have been conducted. He explained that the scheme was a true power directional plan of protection, utilizing carrier current to perform strictly one function. Fast tripping relays in a section are locked out when the fault is external to that section; when the fault is internal, the fast relays will operate. Results of these tests showed that tripping under all conditions could be obtained in a maximum time of 3 cycles on a 60-cycle system.

### Relay Operation From Bushing Potential Devices

A discussion of this subject by H. A. P. Langstaff (Pittsburgh, Pa.) which told of

## Additional Locomotives for the Pennsylvania Railroad

FIVE of the electric locomotives for high speed passenger service on the Pennsylvania Railroad are shown in the test yard of the Erie, Pa., works of the General Electric Company. Each locomotive weighs 190 tons, and is rated as 3,750 hp.

the successful operation and functioning of a number of these bushing potential devices in service, was read by Mr. Langguth. When these devices were used for relays, Neon lamps or a high resistance voltmeter was recommended for checking the voltage which would assist materially in the finding of trouble that might occur within any of the circuits between the bushing and relays. Another point brought out was that no proof was actually obtained of the belief that atmospheric conditions have a limited effect upon the accuracy of the potential as obtained from these devices.

### THE BORIC ACID FUSE

T. G. LeClair (Chicago, Ill.) discussed the features of this new fuse and he felt that the lack of an inflammable liquid filler was an excellent safety measure. He inquired about an opening in the inclosed type for the escape of gases, and the effect of failure when called upon to interrupt a current beyond its capacity.

### SUPERVISORY CONTROL SYSTEMS

M. E. Reagan (E. Pittsburgh, Pa.) described the history of this development. It was interesting to note that the first comprehensive system of remote control and supervision of a large number of operations over a group of common line wires was put into operation at Cleveland in 1922. He also commented on how the fundamentals in these early installations stood the test of time, and are today relatively unchanged. The only addition to the excellent specification for performance appeared to be the anti-pumping control as presented by Mr. Oliver.

J. H. Oliver (Philadelphia, Pa.) discussed the operating experience obtained from the Reading Company's installation, emphasizing the last paragraph of the paper which reported that no trouble had been experienced from induction, no faulty indications or operations had been observed or performed, and no train delays had been caused by failure of the supervisory control equipment. The discusser also pointed out that more maintenance was required where several stations are operated in parallel on the same common conductors than when individual wires and individual systems are used for the control of each station.

### APPLICATIONS AND PERFORMANCE OF AUTOMATIC EQUIPMENT

A. E. Anderson (Philadelphia, Pa.) in his discussion of this subject referred to the extensive use that has been made of the system of the American Gas and Electric Company. With regard to the economics of this equipment he pointed out that investments in automatic switchgear permit reduction in operating costs. In some cases it was possible to remove enough feeder copper to pay for a large share of automatic control. However, he brought out that with the increased reliability and speed over manual operation, together with other attendant developments, economics sometimes are of secondary consideration.

Another discussion by Robert Treat (Schenectady, N. Y.) demonstrated, by quotations from the paper, that a certain course of procedure results in a collateral and perhaps unexpected advantage which is more important or more valuable than the primary objective originally sought. As was found in the paper the automatic substation is often less expensive to operate than an equivalent attended one. But by its reliability, speed of action, and freedom from errors of judgment, the automatic station gives a brand of service which cannot be approached by even the best attended substations.

### REPORT ON TELEMETERING, SUPERVISORY CONTROL AND ASSOCIATED COMMUNICATION CIRCUITS

C. G. Wassal (Cleveland, Ohio) commended the committee for offering such a thorough presentation. He believes the report filled a need felt for a long time and it should result in a much closer coordination between the 3 groups, the manufacturer, the user, and the companies furnishing circuits for such purposes. It also was brought out that the communication circuits used for telemetering require 24-hour maintenance and in addition for open wire routes, alternate routes seemed advisable in case of a base channel failure.

Another discussion of the report was presented by P. MacGahan (Newark, N. J.) and called attention to the importance of the communication line problems. He also told of one of the earliest telemetering systems which was of the frequency class and installed on the Chicago, Milwaukee, and St. Paul Railroad. He explained that the impulses and the current balance systems have entirely superseded the frequency system in modern installations. He also referred to a report on remote metering by the committee on instruments and measurements in the A.I.E.E. TRANS., v. 47, 1928, p. 1164, and he felt that the present report might be considered as an extension of the same subject.

### STRESS-STRAIN STUDIES OF CONDUCTORS

J. A. Inglis (Toronto, Can.) believes the paper on this subject very interesting from the point of change in values of the modulus of elasticity of a cable. He felt it would be interesting to know if during these tests basketing or bird-caging was experienced at end conditions or connections, and if any records were taken of rotation. He also cited the importance of fatigue limits and suggested that it would be most advantageous if they were tabulated for the various metallic cables.

### VIBRATION AND FATIGUE

In connection with this subject F. E. Andrews (Chicago, Ill.) explained that there are several 3-strand conductors now on the market, notably one of high strength material made by the Aluminum Company of America. Inquiry was made about experience with the use of sleeves on this conductor and if any special sleeve was necessary.

M. E. Noyes (Pittsburgh, Pa.) replied to the suggestion in the paper that different types of stranding of cables should be compared to determine their relative ability to dissipate energy by interstrand friction. He explained that this had been done successfully in the laboratory of his company on 120-ft. spans using a decrement method, by Mr. Kimball. The decrement of amplitude was measured from a trace taken after the source of forced vibration had been suddenly disconnected from the cable. This value is then substituted in the Kimball formula. Concerning consideration of new cross-section shapes and new types of stranding, Mr. Noyes called attention to the possibility of severe stress concentrations which might occur at span ends due to abrasions of the surfaces of wires. In his opinion any cross-section shapes of conductor which caused certain strands to stand out sharply would be liable to higher stress concentrations than the usual round cable.

### VIBRATION OF OVERHEAD TRANSMISSION LINES

E. W. Dillard (Boston, Mass.) described field tests and experiences on the Fifteen-Mile Falls transmission line in connection with disruptive corona as a third cause of vibrating conductor. A test span, the exact duplicate of one of the spans on the line, was erected to confirm this hypothesis by experiment under controlled conditions. Rows of sprinklers installed above the span provided precipitation at will. Under simultaneous conditions of low wind velocity (under 4 miles per hour) and precipitation, vibrations were produced in all sizes of conductors from No. 14 AWG stranded copper antenna wire to 795,000-cm. A.C.S.R. with the exception of No. 4/0, 7-strand, hard drawn copper which seemed to have inherent mechanical characteristics which suppressed any tendency toward vibration. Conditions observed on the Fifteen-Mile Falls line and on the California-Oregon Power Company's system showed that vibration occurred on the 2 systems under identical conditions. This data led to several new principles in regard to conductor vibrations.

Another discussion by C. B. Basinger (Cambridge, Mass.) read by F. E. Deck, presented results of experiments made by H. L. Richardson (Cambridge, Mass.) and the author of the paper, at the Massachusetts Institute of Technology, to study the forces which act on a moving conductor surrounded by corona discharge. These studies showed that a force exists which is a function of the voltage on the conductor and of the velocity of the conductor relative to the air. In general, it is necessary for the conductor to be energized above the corona voltage and over the range studied a further increase in voltage increases the force.

### VIBRATIONS DUE TO SLEET

F. E. Andrews (Chicago, Ill.) also discussed this paper and he felt that the subject discussed was that which is generally known as "whipping" rather than "vibration." He also believes the conclusion in the paper, that change in span length or change in tension of the cable does not effect the phenomena, is contrary to generally established formulas for traveling waves in a conductor. To him it seemed impractical to predict whipping by the application of the formulas developed.

Another discussion by L. L. Perry (Chicago, Ill.) gave evidence of extraordinary weather conditions in Illinois and Indiana on March 21, 1932. Conditions produced sufficient dancing of conductors to trip out 132-kv. circuits of both A.C.S.R. and copper. At Chicago the temperature range was only from 29 deg. fahr. minimum to 30 deg. fahr. maximum with a maximum wind of 35 miles per hour. Other conditions were cited and apparently all tripouts occurred at one point, as evidenced by burns on the conductors and ground wires. At this point only, the line had a diagonal run with about a 90-deg. angle with the wind.

A. E. Davison (Toronto, Can.) discussed this subject and cited the importance of keeping it prominently before engineers and executives. He referred to galloping as evidenced within a 100-mile radius of Niagara Falls with sleet loading and winds at 5 to 15 miles per hour. These conditions were shown by Mr. Davison from a film obtained through the kindness of the Niagara, Lockport and Ontario Power Co. In regard to this paper he explained that it correctly pointed out that in earlier references to "lift," "drag" studies were omitted. He felt also that there should be general agreement with the authors' conclusions.

## 1932 Lamme Medal Nominations Due Nov. 1

In fulfilment of By-Law requirements, a second posting is hereby given to the necessity of all nominations for the Lamme Medal for 1932 being submitted not later than November 1, 1932. (See Electrical Engineering, June 1932, p. 417.)

Presentation of the 1931 Lamme Medal was made to Giuseppe Faccioli (F'12) consulting engineer (retired) General Electric Company, Pittsfield, Mass., at the opening session of the Institute's recent summer convention at Cleveland, Ohio.

**Three thousand radio receiving sets** now can operate independently on the same antenna without interfering with each other, according to an announcement by the Western Electric Company. The system is designed primarily for hotels, apartments, and other multiple dwellings, and is arranged to overcome the increasing problems which dwellers in such buildings face in obtaining good antenna facilities for their radios at reasonable cost. The principles employed in long distance telephone circuits are used in this equipment. The receiving system is protected against interferences which the ordinary lead-in wire commonly picks up from sources within a building, and the loss in receiving power usually caused by the great length of lead-in wire and its high capacity to ground is overcome. Each receiving set connected to the system is electrically isolated so that it cannot put any noises back into the system to disturb the operation of others on the line. The receiving set may be of any make the individual chooses. A vital part of the system is the "coaxial conductor" which serves as a lead-in wire. A lightning arrester, repeating coil, filters, an amplifier, and lines radiating throughout the building make it possible for each user to connect his set by plugging into a convenient socket. Smaller forms of this equipment are available also, and are suitable for even the individual home owner with only one radio receiving set.

## Frank J. Sprague Receives Many Tributes

A feature of the meeting honoring Frank J. Sprague (A'87, F'12, HM'32 and past-president) and which was held in the Engineering Societies Building, New York, N. Y., on July 25, 1932, was the presentation to Doctor Sprague of a handsomely bound collection of nearly 500 letters of congratulation and appreciation. The existence of these letters was not known to Doctor Sprague until the conclusion of the meeting when they were presented to him as a complete surprise.

The program, as announced in Electrical Engineering for July 1932, p. 526, included speeches of tribute delivered by Dr. J. H. Finley, associate editor of the New York *Times* and former commissioner of education for New York City, Frank Hedley, president of the Interborough Rapid Transit Company, New York, N. Y., Rear Admiral S. S. Robison, U.S. Navy, retired.

Classifying Doctor Sprague as having "the same relation to electric transportation that Thomas A. Edison bore to electric illumination," Mr. Hedley in his address stated further that "Doctor Sprague has not rested with the mere inventing or suggesting of new methods. He has recognized that the world often is too busy to pay attention to new and advanced ideas which are considered revolutionary, or to give them a trial unless forced to do so, and he has made it his business to do the necessary forcing. . . . He knows what it means to have the signals set against him and to be forced onto a side track and delayed. Nevertheless . . . his inventions have proved worth while and he had sufficient faith in them to fight for them, even when confronted with discouraging conditions and fierce competition." Mr. Hedley mentioned the modern multiple unit electric train control as exemplifying the importance of Doctor Sprague's contributions to transportation developments, and said " . . . The traveling public owes and always will owe a tremendous debt to him."

Doctor Sprague acknowledged the tribute in a short response, expressing his thankfulness at having been able to be of service to his fellow men in facilitating their convenient transportation. After mentioning briefly some features of his own work, Doctor Sprague ventured the opinion that although other modes of transportation are becoming more important, the railroads still remained the "vital foundation of the country." He stated further that "it would be folly to predict in the present low state of competitive traffic and world wide financial depression, that general electrification is advisable or even permissible in the near future. However, if some of the hundreds of millions of capital which the national government is ready to dole out for unproductive public works were diverted to legitimate and sane electric railway equipment a long step would be taken toward economic recovery."

Doctor Gano Dunn, past-president of the Institute (1911–12) presided over the meeting as chairman of the anniversary committee which included in its membership list a galaxy of names prominent in professional, educational, electrical, and transportation fields. Dr. C. T. Hutchinson (F'12) consulting engineer of New York City served the committee as its secretary, while Frank Hedley, W. B. Potter (M'96), G. A. Richardson (A'08), and F. H. Shepard (F'24) served the committee as its working unit.

**Wood Poles for Overhead Electrical Lines.**—The Bureau of Standards of the U.S. Department of Commerce has issued Handbook No. 16 on the subject of "Wood Poles for Overhead Electrical Lines." It is for sale by the superintendent of documents, Washington, D. C., price 10 cents, and contains considerable data on this subject.

## Doctor Flinn Receives Honorary Degree

On June 17, 1932, Dr. A. D. Flinn, who since 1922 has been director of Engineering Foundation, New York, N. Y., received the honorary degree of doctor of engineering from Worcester Polytechnic Institute, Worcester, Mass. Doctor Flinn, a native of the state of Pennsylvania, received his bachelor of science degree from Worcester Polytechnic Institute in 1893, and in 1927 received the degree of doctor of applied science from the University of Louvain.

Doctor Flinn, a civil engineer, has been concerned for many years with the activities of the entire engineering profession. Between 1895 and 1918, he was successively engineer with the Metropolitan Water Works, Boston, Mass., managing editor of *Engineering Record*, New York, N. Y., engineer on the Croton Aqueduct Commission, and deputy engineer and deputy chief engineer of the Board of Water Supply, New York, N. Y. (Catskill aqueduct). Since 1918 his office has been in the Engineering Societies Building where he has served since that date as secretary of the organization carrying successively the names, United Engineering Societies, Engineering Foundation, Inc., and United Engineering Trustees, Inc. From 1918 to 1921 he also was secretary of the Engineering Council. In addition to being director of Engineering Foundation since 1922, he has been secretary of that organization since 1918.

Doctor Flinn was a member of the National Research Council, 1918–1923, and chairman of its division of engineering 1920–1923. His technical affiliations include fellow of the American Association for the Advancement of Science, member and past director of the American Society of Civil Engineers, and member of the American Institute of Mining and Metallurgical Engineers, the American Iron and Steel Institute, and the American Society for Testing

Materials. He is honorary foreign member of the section of engineering societies of the Masaryk Academy, Czechoslovakia, Knight, Order of the White Lion, Czechoslovakia, and member of the Japan Society, Sigma Xi, Sigma Alpha Epsilon, the Engineers' Club, and the Century Association. Doctor Flinn was a joint author of the "Waterworks Handbook" published in 1916, and has been a contributor of numerous papers and articles on engineering topics.

## Airship Institute Dedicated at Akron

The new Daniel Guggenheim Airship Institute at Akron, Ohio, was dedicated with impressive ceremonies on Sunday, June 26, 1932. The program included a communication from Harry F. Guggenheim, president of the Daniel Guggenheim Foundation for the Promotion of Aeronautics, and addresses by Dr. G. F. Zook, president of the University of Akron, and Dr. R. A. Millikan (M'22), chairman of the executive council of the California Institute of Technology, Pasadena. This Airship Institute at Akron has been made possible by a gift of $250,000 from the Guggenheim foundation to both the University of Akron and the California Institute of Technology for the study of lighter-than-air problems. The gift was supplemented by $100,000 from the city of Akron. After expenditures for building and equipment, funds remained for the conduct of research work during the next 5 years. A most important part of the equipment is a vertical wind tunnel, the largest in existence.

On the second day, June 27, a conference was held on progress and problems of research in lighter-than-air craft, with Dr. R. A. Millikan as chairman. Among the large number of speakers, all outstanding experts in aeronautical engineering and research, who took part in this conference are: Karl Arnstein, vice-president in charge of engineering, The Goodyear-Zeppelin Corporation; Garland Fulton, chief of lighter-than-air section, Bureau of Aeronautics, U.S. Navy Department; J. C. Hunsaker, vice-president and general manager, The International Zepplin Corporation; Theodor von Karman, director, The Daniel Guggenheim Airship Institute; W. E. Kepner, Air Corps, Wright Field; and C. B. Fritsche, general manager, Detroit Aircraft Development Corporation. The subjects discussed during this conference fall under the following headings:

1. Aerodynamics of airships.
2. Thermodynamics.
3. Meteorology.
4. Structural analysis.
5. Instruments.
6. Engines and power plants.
7. Materials.
8. Aerostatics.

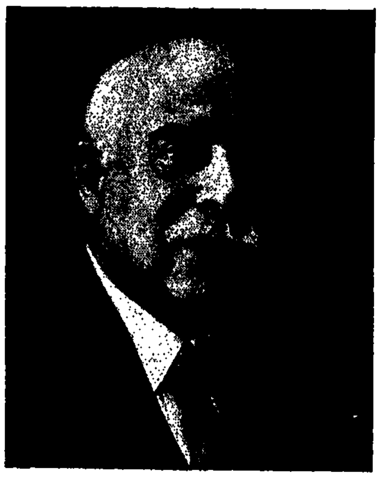
Dr. C. E. Skinner (A'99, F'12, and junior past-president) served as the representative of the A.I.E.E. at the exercises on June 26 and 27. The following statement, taken from a letter of Doctor Skinner's reporting the exercises, summarizes the purpose of The Daniel Guggenheim Airship Institute and its relation to electrical engineering:

"This Institute is to be devoted entirely to the study of problems incident to the building and operation of lighter-than-air craft. Many of the problems which have been selected for study and experiment have a very direct relation to the problems in electrical engineering, and I have no doubt that on this account our Institute would do well to keep in touch from time to time with the work of The Daniel Guggenheim Airship Institute.

"The problems of most direct interest are probably those having to do with the movement of air through passages, the surface friction of air over bodies, the transfer of heat, etc. These all have direct relation to the problem of ventilation in electrical machinery. There are many other problems in connection with the physical characteristics of construction and materials, the study of stresses and strains in structures, etc., which have a less direct bearing but which are similar to problems encountered in the construction of electrical machinery and apparatus."

## Doctor Burgess, Leading Physicist, Dies

George Kimball Burgess, director of the U.S. Bureau of Standards, Washington, D. C., died suddenly on July 2, 1932, of cerebral hemorrhage. Doctor Burgess was born at Newton, Mass., in 1874, receiving his bachelor of science degree from Massachusetts Institute of Technology in 1896, and the degree of doctor of science from the University of Paris in 1901; honorary degrees of doctor of engineering were conferred upon him by Case School of Applied Science, 1923, and Lehigh University, 1925.



GEORGE K. BURGESS

Between 1896 and 1903, Doctor Burgess taught physics at M. I. T., the University of Michigan, and the University of California. Since 1903 he has been connected with the Bureau of Standards, being successively assistant physicist, associate physicist, physicist and chief of the division of metallurgy, and since 1923, director, in which position he succeeded the first director, the late S. W. Stratton. High temperature measurements and metallurgy were the fields in which most of his scientific work as a physicist was concentrated; among his noteworthy achievements are the application of optical pyrometry to metal in furnace and rolling processes. His work on standards for light measurement, details of rail structure, causes of rail failure, and many other phases of metallurgy was outstanding and has continued to be of considerable assistance to workers in these fields. A large expansion of the bureau's activities occurred while he was director, and he was responsible for the development of the research associate system under which industries carry on research work at the bureau through their own employees advised and assisted by the staff experts of the bureau.

Doctor Burgess contributed freely of his time to the work of scientific and technical societies. Among the societies of which he was a member are the National Academy of Sciences, American Society for Testing Materials (past-president), National Research Council (chairman), American Society for Steel Treating (past-president), American Engineering Standards Association (director), the American Institute of Mining and Metallurgical Engineers, the American Physical Society, and the Optical Society of America. He was an honorary member of the American Foundrymen's Association, and the Japanese Society of Mechanical Engineers. He had also been chairman of the federal specification board and the national screw thread commission, and a member of the national advisory committee for aeronautics. In 1927 he was U.S. delegate to the seventh international conference on weights and measures in Paris, in 1929 was U.S. delegate to the world engineering congress in Tokyo, and had been president of the Annual Conference on weights and measures. He was a member of Sigma Xi fraternity and the Cosmos Club. In addition to many scientific articles and papers, he was the author of "Recherches sur la constante de Gravitation," 1901; "Experimental Physics—Freshman course," 1902; and "The Measurement of High Temperatures" (with H. Le Chatelier) 1912.

## Insulation Committee to Meet in Baltimore

The electrical insulation committee of the National Research Council has announced its plans to hold its regular annual meeting at The Johns Hopkins University in Baltimore, Md., at the same time that the A.I.E.E. Middle Eastern District is meeting there. This will facilitate a joint meeting of these organizations tentatively scheduled for Monday afternoon, October 10, at which time 4 papers in the field of high voltage underground cable insulation and performance will be presented.

Two other technical sessions of the electrical insulation Committee will be held. In those sessions the results of recent research in the fields of dielectrics and insulation will be presented in the form of informal reports of progress made by manufacturers, scientific societies, and governmental and university laboratories. These sessions are scheduled to be held at the School of Engineering, Johns Hopkins University, under the general supervision of Dr. J. B. Whitehead, who is chairman of the committee.

# Letters to the Editor

CONTRIBUTIONS to these columns are invited from Institute members and subscribers. They should be concise and may deal with technical papers, articles published in previous issues, or other subjects of some general interest and professional importance. ELECTRICAL ENGINEERING will endeavor to publish as many letters as possible, but of necessity reserves the right to publish them in whole or in part, or to reject them entirely. Statements in these letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the American Institute of Electrical Engineers.

## Labor and Engineering Progress

*To the Editor:*

Mr. William Green's contribution to the symposim on "Has Man Benefited by Engineering Progress" (see "Labor and Engineering Progress," ELECTRICAL ENGINEERING, May 1932, p. 318–9) is, to my mind, the most encouraging contribution yet received.

Its depth of view and understanding is wonderful evidence that one need not necessarily have had a typical engineering education to have the engineer's method of approaching a difficult subject.

Most of all, it is encouraging to me, because it contains the first invitation that engineers have received from one not in their profession, to expand their field of usefulness to mankind.

We, as engineers, have had exceptional advantages and some of us have had the courage to say that our methods should be extended into other fields, including that of human relations, but no such suggestion has come to us from bankers, lawyers, or politicians.

That such an invitation should first come from a self-made man, like Mr. Green, who is president of the world's greatest labor organization, is indeed encouraging indication that engineering methods are beginning to be appreciated outside the profession.

I sincerely hope that the Engineering Foundation and American Engineering Council will both find ways and means to cooperate with Mr. Green.

Very truly yours,
W. S. MOODY (F'12)
(Consulting Electrical Engineer,
155 Dawes Ave.,
Pittsfield, Mass.)

*To the Editor:*

The article by Mr. William Green on "Labor and Engineering Progress" in ELECTRICAL ENGINEERING for May 1932, p. 318–9, is a fine contribution to the economic recovery of the country.

There is no doubt but that the present machine age with its mass production, efficiency systems and the infinite number of labor saving devices, requires a compensator in the form of a shorter work week.

When the salesmen find that their former customers cannot buy their goods due to their being out of employment, business suffers, also machinery and plants become financially insecure.

Real prosperity demands that the maximum number be employed. At no additional expense to the employer the present man-hours of work should be apportioned so that the weekly amount of work will be done by more workers. The work week should be shortened, keeping the same hourly rate of pay, until all unemployment is absorbed. We are being forced to this conclusion. The longer the delay the harder it will be to recover.

When all who want to work are employed, business will soon pick up, with leaps and bounds, due to available money to spend, which will create a healthy demand. Salesmen will be happy and salaries will rise as the general prosperity increases.

Production will be balanced by work hours.

Very truly yours,
H. S. HALL (M'25) (616 East
8th St., Brooklyn, N. Y.)

*To the Editor:*

After reading that most commendable article, "Labor and Engineering Progress" by William Green, which appeared in ELECTRICAL ENGINEERING for May 1932, p. 318–9, the writer was moved to wonder if this article and articles of a similar nature in this series, as well as the President's message, have made any deep impression on engineers at large. It seems that most engineers are all too prone to lose themselves in the maze of technical work and lose sight of the less tangible problems mentioned in above paper, the equitable distribution of goods, profits, and labor. These are certainly complex problems which are worthy of an engineer. Since the engineer is largely responsible for the creation of the giant, machine age, which is threatening to annihilate us in its unguided and staggering course, surely he is not going to sit down and leave to bungling politicians the task of providing a system of control for his robot. In other words, the engineers' work is only partly done and he must devote some of his time to the solution of these important problems.

It does not seem enough to utter a mild appeal to members at large to take a more active interest in such matters or to leave the burden of their solution to a few engineers who are actively engaged in politics, for it seems that a few men with ideas cannot put them into effect without strong support. If anything of value is to be arrived at, it requires concerted effort from the engineering body as a whole. Of course, every engineer should acquaint himself more with the matters of government, finance, and politics than he has done in the past, and should have no hesitancy in coming forward with criticisms, ideas, etc., at any time. Now it seems that this concerted effort of the engineers should be directed by the various engineering societies, that is, why should not each engineering society have a special committee of notable engineers to investigate and present reports and recommendations on these problems from time to time in the same manner they would investigate a special phase of technical work. Thus the engineers as a body would be in a position to offer solutions to pressing problems and to exert the necessary pressure for their adoption in industry and government. If the President had such a body behind him, he could effect many of the necessary reforms which he, no doubt, has in mind and is at present almost powerless to carry out due to strong group opposition. Therefore, it is time the engineer cast aside his habitual reserve and deference to the politician and join the fray in a concerted effort to find a scientific solution to the problems which urgently need solving.

It is not assumed that all our difficulties would be solved by the magic touch of the engineer, or we would arrive at the millennium at once, but it certainly seems that more active and concerted effort by the engineers in the solution of these difficulties would be preferable to experiments of bolshevism or socialism which may come unless the machine age is put under sensible control. No doubt the suggestions outlined above will provoke some criticism and suggestions. If so, this letter has accomplished its purpose.

Very truly Yours,
J. R. HANGO (A'31)
(Arvida, P. Que., Canada)

## Reactive Power Units and Terms

*To the Editor:*

I desire to call attention to the apparent disregard of the "unit of reactive power" and the term "reactive power."

The adoption of this unit—the "var"—and the provisional adoption of the term "reactive power" by the International Electrotechnical Commission in session at Oslo, July 1930, were reported in ELECTRICAL ENGINEERING for February 1931, p. 142.

It would be unreasonable to expect all authors to adopt these conventions immediately, but I do believe that our committee reports should utilize any and all definitely adopted nomenclature, thus hastening its general usage.

It is quite possible that I have overlooked some article using the "var" but to the best of my knowledge the unit has not been used until in A. E. Kennelly's article, "Recent Developments in Magnetic Units," in ELECTRICAL ENGINEERING for May 1932, p. 343–5. The adoption of a unit of reactive power comparable with the unit (watt) of active power is a valuable advance, as the "reactive voltampere" has been a cumbersome unit.

In respect to the term "reactive power," though only provisionally adopted, the desirability of its use in conjunction with "active power" is, I believe, obvious. Reactive voltamperes as a term has no more excuse for its use than has its complementary term active voltamperes. By refraining from the use of either of these (reactive voltamperes and active voltamperes) the unit of apparent power—the voltampere—is available without the slightest need of the qualifying prefix "apparent." Thus 2 distinct phases of the power expression are provided:

1. **Apparent Power = Active Power $\pm j$ Reactive Power**
2. **Voltamperes = Watts $\pm j$ Vars**

In a recent committee report, "Proposed Definitions of Terms Used in Power System Studies" (No. 31M2) and some other articles, the convention $P \pm jQ$ has been used to represent the right hand side of the above equations. This is leading us directly into an ambiguous situation. $P$ is commonly accepted as the symbol for power. And power has been commonly used interchangeably with active power, though it is becoming more apparent that this is a serious error—as attested by the increasing interest in the reactive power component in energy sales considerations, and the difficulty of explaining this new factor to the layman.

It is certain that a considerable amount of educational effort will have to be expended to clarify this situation. Why not make as much gain as is possible since some revising is necessary. Two lines of procedure are suggested to me. They are:

1. Place power on the left side of eq. 1, that is, drop the "apparent" from power as we did above from voltamperes, making the unit of power the voltampere, of active power the watt, and of reactive power the var. This is the preferable though more radical change.

2. Continue the use of power in lieu of "active power" and adopt some other term for reactive power (quadro is suggested to me by the symbol $Q$). "Apparent power" is still a source of trouble and should be replaced by some other term.

According to A.I.E.E. Standard, "Letter Symbols for Electrical Quantities" (17g1), $A$ and $S$ are available for assignment as symbols. $A$ is readily adaptable as the symbol for active power in suggestion 1 above.

$$\text{Power} = \text{Active Power} \pm j\,\text{Reactive Power}$$
$$P = A \pm jQ$$

For active power the symbol $A$ could nicely represent apparent power, although the letters $VA$ are quite suitable:

$$\text{Apparent Power} = \text{Power} \pm j\,\text{Quadro}$$
$$VA = A = P \pm jQ$$

I further wish to indicate that I favor the convention watts $\pm j$ vars to represent active power and leading reactive power as tentatively adopted by the committee.

Very truly yours,
FRED B. IRWIN (A'31)
(1430 Hawthorne Avenue,
Portland, Oregon)

## The Way Out of the Depression

*To the Editor:*

In response to the invitation to discuss the article "Progress Is the Way Out of the Depression" by Mr. A. W. Berresford in ELECTRICAL ENGINEERING for December 1931, I am sending the following: The first paragraph contains a statement about the depression that seems extraordinary for an engineer to make. "There is little of value at the moment in attempting to isolate and correct the major causes." Can we imagine this attitude applied to any engineering work? Can we imagine an engineer saying that there is little value in trying to isolate the causes after a bridge or a dam failure? Can we imagine an engineer saying, after a bridge failure, that the causes will gradually emerge as time provides a perspective? To be sure, study of the causes will not rebuild the bridge, but it may prevent a second failure.

If the solution is left to time, we are likely to see the economic and social errors that produced the dark ages repeated; in fact, much of the "quantity of understanding" which Mr. Berresford says has increased so much within the last 18 months seems to be a reversion to the errors refuted by the economists of the last 200 years.

"The mere fact that stabilization of employment is economically dependent upon controlled production, and consumption dependent upon stabilized employment, will unite all elements in a common demand for that solution." This statement forms the basis of many of the popular fallacies, chiefly because it is so plausible. But nature has decreed otherwise. As long as the farmer does not know whether he will get 10 bushels or 40 bushels when he plants an acre of ground, stabilized production is impossible. To attempt stabilization probably will cause greater instability.

Consider a state with industrial activities stabilized to the greatest possible extent. Each company has its quota of production with the men for whom it is responsible. Now nature produces an unexpected crop, 25 per cent greater than the farmers had planned. This leaves a surplus for next year, so that there should be a reduction of 25 per cent in the number of men on the farms for the next year. With every industry stabilized where are they to go? Instead there is an unemployed surplus of men on the farms with resulting distress and reduced purchasing power. This in turn affects the industries, reducing the possibility of employment, and consuming reserves if any have been accumulated. The attempt to maintain stability is an attempt to thwart economic laws; but the laws will win and worse troubles develop.

What we need is flexibility, not stability. We need a mobile labor force as well as flexibility of management. We need industries that can increase or decrease their working forces according to conditions, and we need an economic inducement to make them increase and decrease at the right time for the public good.

One simple inducement which can be applied without much change in the present economic structure consists of an expansion of the currency with falling commodity prices. When a surplus crop is produced, the currency should be expanded to hold a large part of this crop over for a future year. The expansion of currency will result in stimulating industrial demand so as to provide jobs for the farm help released by the excess crop. This is only one step, and it will not prevent unemployment or business depressions altogether, but it is a step in the right direction. A more important step is the reorganization of education; but that is too complicated a problem to discuss here. The important thing to keep in mind is that whatever action is taken, it should be to provide greater flexibility, to make it easier for men to change from one kind of work to another as conditions change. It should tend to break the ties that now too strongly bind men to the jobs where they long have worked.

Very truly yours,
A. W. FORBES (A'12) (Forbes
and Myers, 172 Union St.,
Worcester, Mass.)

## Paralleling Rotor and Stator

*To the Editor:*

In the March issue of the ELECTRICAL ENGINEERING appeared an article based upon an interesting paper by Conrad and Warner: "Induction motors with parallel rotor and stator." The synopsis of the complete paper points out that "this method of operation was new to the authors and to several eminent induction motor designers and as no reference has been found to others employing this principle . . ." etc. In connection with this statement, it may be of some interest to both authors and readers, to learn that the same subject has been covered in the Archiv fuer Elektrotechnik, v. 20, 1928, p. 162, by Tolwinsky and Hochberg (Leningrad) in a paper (German): "Asynchronous operation of a three phase induction machine with stator and rotor connected to the same supply system."

The information (theoretical developments and experimental results) contained in the German paper is supplemented by a few valuable remarks concerning the practical application of the principle involved. After pointing out the disadvantage of the low power factor at small loads, the Russian authors emphasize the fact that the superposition of a low-frequency current wave on the power supply system currents will be rather undesirable in so far as it will cause flickering of lights connected to the same system. As a consequence it must be feared that public utilities may prohibit application of said principle to motors connected to their power systems.

Very truly yours,
A. VAN NIEKERK (A'24)
(Designing Engr., Westinghouse Elec. & Mfg. Co.,
E. Pittsburgh, Pa.)

## Mechanical Analogs of Electric Circuits

*To the Editor:*

The use of electrical analogs for mechanical systems is based on definite analogies of form between the mathematical equations which describe the behavior of each type of system. The design of a mechanical phonograph (see "Methods of High Quality Recording and Reproducing of Speech and Music, Etc.," J. P. Maxfield and H. C. Harrison, *Bell Sys. Tech. Jl.*, v. 5, July 1926, p. 493) by electrical engineers some years ago apparently gave an impetus to the use of electrical analogs, although there has been comparatively little written on the subject. Skilling (see "Electric Analogs for Difficult Problems," H. H. Skilling, ELECTRICAL ENGINEERING, Nov. 1931, p. 862–5) has shown an application in a particular problem and has outlined some of the important advantages of the use of equivalent electric circuits.

The opposite process—use of mechanical analogs for electric circuits—does not appear to offer comparable advantages, particularly as far as circuit theory and ease in determining experimentally the action of a system are concerned. In certain cases, however, mechanical concepts may be of assistance to the electrical engineer. Several instances are cited below.

Consider Newton's Law of Motion

$$F = \frac{dG}{dt}$$

where

$F$ is the vector resultant of the forces acting on all the particles of a mechanical system

$G$ is the vector sum of the momenta of all the particles.

If $F = 0$, then $G$ is constant, which is the well-known law of the conservation of linear momentum.

The electrical analog of momentum (mass times velocity) is magnetic flux linkages (inductance times current) and the equivalent of the mechanical law is the electrical principle that in a circuit or group of circuits in which the resistance is small the flux linkages remain constant (approximately) when the forces (e.m.f.'s) are withdrawn, as on short circuit. (A capacitor gives rise to a force obeying Nooke's law in the electric-mechanical analogy.) This principle of electric circuits has not been very widely used, so that a comparatively recent writer (see "Short-Circuit Currents of Synchronous Machines," R. F. Franklin; A.I.E.E. TRANS. v. 44, 1925, p. 863–72) has felt it necessary to refer to a proof. That this analog of one of those laws of mechanics which are considered most fundamental is an electrical principle which has not been utilized by engineers for so very many years lends support to the thought that mechanical laws less prominent than the conservation of momentum may yet point out electrical principles of value in particular cases. The integral developed by Carson and applied by him to the analysis of electric circuits to which the usual circuit laws (Kirchoff's laws) were not readily applicable has been shown to have been used in equivalent mechanical form before electric circuits were known.

Experience indicates that most students, including those with some advanced training, consider work and kinetic and potential energies from the mechanical viewpoint, particularly when they understand the electric-mechanical analogy. Thus work is force times distance, hence e.m.f. times charge, while kinetic energy is $^1/_2\, mv^2$ for a particle, hence $^1/_2\, Li^2$ for a simple series circuit, etc. The magnetic energy is not always called kinetic energy, and the electric field energy is not always called potential energy, but it is of advantage to understand the analogy when for example the action of a system involving both electric and mechanical circuits such as a telephone receiver is analyzed. (See "Theory of Telephone Receivers," R. L. Wegel, A.I.E.E. JOURNAL, v. 40, 1921, p. 791–802. In this paper the total kinetic energy of an electromechanical system is set up and used in the Lagrangian equations to analyze the system.) The use of many advanced dynamical principles (Lagrange's equations for example), which are usually equally applicable to electric circuits, requires the setting up of expressions for the total kinetic and potential energies of the complete mechanical, electrical, or electromechanical system. It should be noted that the possibility of application of these mechanical principles to pure electric or electromechanical systems may be ascribed to the (formal) equivalence of mechanical for electric systems rather than vice versa.

Another conceivable case in which known mechanical principles might be used is in connection with the equilibrium and stability of an electromechanical system. The mechanical principles now available should suffice if need arises.

None of the above examples is very important in itself. They have been offered simply to illustrate some of the advantages to be derived from the consideration of mechanical "circuits" as analogs of electric circuits.

Very truly yours,
J. G. BRAINERD (A'32) (Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa.)

## Junior Engineers Plan Industrial Projects

*To the Editor:*

The article "Junior Engineers Plan Industrial Projects" appearing in the July 1932 issue of ELECTRICAL ENGINEERING, p. 523, is of considerable interest.

The procedure of the program described in the article should be of interest to all members of the Institute Sections and Branches. There can be no doubt that the organization of the junior members within their respective local branches will produce an active continued interest among the young members.

The forming of these hypothetical companies and the solution of the problems involved should give the junior engineer an invaluable practical experience, as well as a chance to show his initiative and ability when confronted with a definite responsibility.

Local firms and public utility organizations, also elder members of these concerns or Institute Sections, should cooperate with the junior groups in offering their criticisms, suggestions, and experience.

This, then, is a very definite step in demonstrating to the junior engineer or graduate in what line of specialization he is more recommended, as well as forming a fraternal bond between the junior member and the profession.

Very truly yours,
HARRY A. ETKIN (A'26)
(520 McClellan St., Philadelphia, Pa.)

## Consumption, Production, Distribution

*To the Editor:*

In the progress report of American Engineering Council ("The Relation of Consumption, Production, Distribution," ELECTRICAL ENGINEERING, June 1932, p. 373–9), it seems to be assumed that savings have been too great. As a check on this theory I tried to secure the best data that I could find on the actual savings of the country, and have plotted the values in a curve, Fig. 1. This curve shows an estimate of the actual total volume of property, which is the actual measure of savings, as estimated by the U.S. Census and by the National Industrial Conference Board. I have corrected the figures for increase in population and for the change in the value of the dollar, giving the result in figures that are supposed to represent actual property, not dollars. It is plotted to a logarithmic scale so that the same slope of the curve indicates the same rate of increase at any point on the curve.

Of course the figures are not accurate. No one can tell just how much property you or I have, and no one can tell exactly the relative value of the dollar in times 50 years apart. But the figures are honest efforts to give comparable data, and the big differences shown leave us quite sure that they do represent a real change.

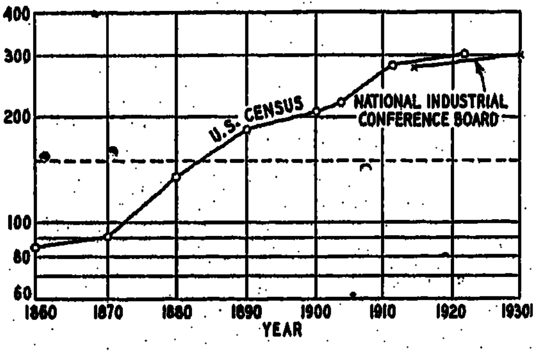


**Fig. 1. Per capita wealth of the United States expressed in index numbers. The scale is so selected that the slope of the line is the same at all positions if the per cent increase is the same**

First we see that the decade of the civil war was a time of slow increase in wealth, as would be expected. There was another slow rate of increase at the time of the 1893 depression, whether cause or effect is hard to tell. But the slowest rate of all has been the last few years. Unfortunately both recent figures include the period of the war, but the fact that both the latest figures of the census and the National Industrial Conference Board agree so closely would lead us to think that increase of wealth has not yet made its normal start, after the war.

Modern machines are expensive, and modern industry cannot operate without a greatly increased volume of capital. It is impossible to tell how much of the wealth shown by the curve is capital, but this failure of wealth to make a normal increase leads to the natural conclusion that capital has also failed to make its increase, and without this increase industry cannot function properly. This is merely one fact that supports the conclusion that one major cause of the present troubles is a shortage of capital. Therefore any method toward relieving the depression must be watched to see that it does not cause any further drain upon savings and capital. If it does it will probably cause more harm than good.

Very truly yours,
A. W. FORBES (A'12)
(Forbes & Meyers, Worcester, Mass.)

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(Editor's Note: This letter is the second by Mr. Forbes discussing the economic problems covered in American Engineering Council's progress report.)

# Standards

## Wires and Cables

Three standards for wires and cables were approved by the American Standards Association on May 21, 1932, as follows: "American Standard Definitions and General Standards for Wires and Cables" (C8a-1932); "American Tentative Standard Specifications for Weatherproof (Weather Resisting) Wires and Cables" (C8k1-1932); "American Tentative Standard Specifications for Heat Resisting Wires and Cables" (C8k2-1932).

The first of these, the definitions and general standards for wires and cables, includes definitions and standards of a general character applicable to wires and cables for power purposes, and comprises a rearrangement of A.I.E.E. standard No. 30 of October, 1928, which has been brought up to date with certain additions and deletions. It contains definitions for the various types of wires and cables, conductivity standards, designation standards, high voltage test standards, insulation resistance standards, capacitance or electrostatic capacity standards, and maximum temperature limits.

The specifications for weatherproof wires and cables (C8k1-1932) cover weatherproof wiring and cables and the materials used for coverings and saturating compounds as applied to metallic conductors. The specifications are divided into the following headings: covering; saturating compound, which includes the tests therefore; stranded cables, including sizes of conductors and the stranding therefore; standard weights; a table of weights and weatherproof wires and cables; samples for tests; tests on copper conductors; and explanatory notes.

The specifications for heat resisting wires and cables (C8k2-1932) cover the usual type of heat resisting covering commonly known as "slow burning" as applied to metallic conductors for use in hot, dry locations where the other types of insulation would not long endure, or where the presence of large masses of inflammable materials would be objectionable. As explained in the standard itself, "There are many types of heat resisting materials used for insulating electrical conductors, but no attempt is made in this specification to cover anything but the so-called 'slow burning' insulation. The various types of asbestos coverings and enamels are for special purposes and are generally put out under trade names."

Printed copies of these documents on wires and cables will be available in the near future.

## Radio

Two new national standards for radio were approved by the American Standards Association on May 21, 1932, as follows: "Standard Vacuum Tube Base and Socket Dimensions" and "Manufacturing Standards Applying to Broadcast Receivers." These standards were developed by the sectional committee on radio working under the procedure of the American Standards Association, with the Institute of Radio Engineers and the A.I.E.E., the directing sponsors.

The first of the standards applies to certain details in the manufacture of broadcast receivers, which it is desirable to have uniform in the sets of all manufacturers; the second standard specifies dimensions for many of the principal types of bases and sockets of vacuum tubes used in both receiving and transmitting. The types of base covered in the standard are 4-pin bases of the large and small type; large 4-pin base without bayonet pin; large 5-pin base without bayonet pin; 4-pin transmitting tube base; large transmitting tube base: 4-pin sockets for receiving tubes; and 5-pin sockets for receiving tubes. The standard also specifies dimensions for terminal caps for both receiving and transmitting tubes and for connections between the tube elements and the pins.

The manufacturing standards applying to broadcast receivers establish a national standard for the frequency range of receivers from 550 kc. (545.1 m.) to 1,500 kc. (199.9 m.). The rating and design of socket-power devices and electric radio receivers are to be standardized for operation on from 105 to 125 volts. A standard test for quality of soldering of cord tips or terminals to radio cords also is provided. This test is a straight pull of 5 lb. applied to the cord tip or terminal. Other details for which standard dimensions are established are cord tips, binding posts, cable terminals, radio plugs and jacks, and pilot lamps. There also are standard definitions for the various parts of radio receivers. Information with regard to these standards may be obtained from the American Standards Association, 29 West 39th Street, New York, N. Y.

## Code for Protection Against Lightning

The sectional committee for the code for protection against lightning, working under the procedure of the American Standards Association and the sponsorship of the A.I.E.E. and the National Bureau of Standards, has completed a revision of parts I and II of the code. The original code was printed as "Miscellaneous Publication No. 92 of the Bureau of Standards," and information with regard to the proposed revision may be obtained from the chairman of the sectional committee, Dr. M. G. Lloyd, Bureau of Standards, Washington, D. C.

## Proposal Made for Emergency Lighting Code

The National Electrical Manufacturers Association has asked that consideration be given by the American Standards Association to the preparation of a code for emergency lighting. It states that for some time their codes and standards committee has been considering codes for lighting systems designed to insure adequate illumination for emergency use in such places as theaters, hospitals, schools, and other buildings. While there are many state and municipal codes governing such installations, there is little uniformity among them. At various times attempts have been made to incorporate rules governing these installations in the National Electrical Code and the National Electrical Safety Code. This proposal of N.E.M.A. now will go before the standards council of the American Standards Association.

## Test Code for Transformers

The standards committee of the Institute has asked that attention be called again to the "Test Code for Transformers." This code, which is the first of a proposed series of test codes covering electrical machinery and apparatus, has been out in its preliminary form for criticism and suggestion since October 1931.

In order to determine the performance characteristics of electrical machines, methods of testing have been developed and are in common usage. It is the purpose of these test codes to provide in convenient form the more generally applicable and accepted methods of conducting and reporting tests of a commercial nature and applying to the fulfilment of performance guarantees. In general the reception of this code has been favorable. Suggestions of a helpful nature have been received and the committee hopes this notice will result in a final clearing up of any debatable points so that publication in final form may be undertaken shortly. Copies of the preliminary report on the code may be obtained without charge. Address all communications to A.I.E.E. headquarters, 33 West 39th Street, New York, N. Y.

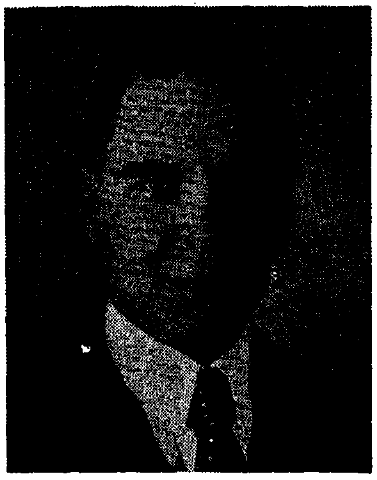
# Personal

Joseph Slepian (A'17, F'27) consulting research engineer of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., upon June 12, 1932 received the John Scott Medal for his "discoveries in the field of the deionization of gases and fundamental and outstanding inventions involving these discoveries." This award carries with it besides the medal and certificate, a premium of $1,000 cash; it was presented to Doctor Slepian with due ceremonies at the Union League Club of Philadelphia. The award was established by John Scott, a chemist of Edinburgh, Scotland, who in 1816 bequeathed to the city of Philadelphia a fund of $4,000, the income from which was "to be distributed to ingenious men and women who make useful inventions...." After the fund had grown to $100,000 in 1917, court orders enlarged its use and specified that the premiums should be awarded "for inventions that will be useful to mankind in the development of chemical, medical, and any other science, or development of industry in any form; the test being that it may add to the comfort, welfare, and happiness of mankind." Doctor Slepian is a Bostonian by birth; his degrees of A.B., A.M., and Ph.D. were all won at Harvard University, the last one being conferred upon him in 1913, with mathematics his majoring subject. The winter of 1913 was given over to a semester at Göttingen University, Germany, and the following spring, to a semester at Sorbonne University, Paris, France. For a year he was instructor in mathematics at Cornell University, and in 1916 he joined the Westinghouse Company's East Pittsburgh force as an apprentice. His promotion to research engineer took place the following year, and in this and in a consulting capacity he has rendered exceptional service to his company. His conspicuous work upon circuit interrupting devices and his use of the unique principle of deionization in the destruction of powerful and violent electric arcs have been important contributions to the field of electric power transmission and distribution.

JOSEPH SLEPIAN

H. L. Wills (A'20) assistant to the vice-president, and also general manager, of the Georgia Power Company, Atlanta, Ga., participated in the A.I.E.E. 1931 national prize for best paper in engineering practise awarded the symposium on coordination of power and telephone plant, composed of 4 parts of which the paper, "Status of Joint Development and Research on Noise Frequency Induction," by Messrs. Wills and Blackwell was a part. Born in Burlington, Vt., he started an apprenticeship in the machinist's trade at the early age of 14. His next undertaking was in the capacity of transitman for the Wisconsin Central Railroad. By 1885 he was assistant to the operating engineer of the Schuyler Arc Light Plant, and from that time on over an extended period of years he continued to hold positions of increasing responsibility. In 1902 he joined the Georgia Railway and Electric Company, at Atlanta, to assume charge of the meter and maintenance repair shops, a service which he continued for 6 years. During the latter portion of his stay with this company, he was directing these 2 departments and also in charge of the contract department. His service as general manager of the Savannah Lighting Company was from 1908 until 1912, when he joined his present company, the Georgia Power Company, as district manager, with offices at Macon, Ga. Upon consolidation of his company with the Georgia Railway and Power Company, he was transferred to Atlanta, Ga., as special detail engineer. His long affiliation with the Georgia Power Company has included the various duties of resident engineer on the Tallulah Falls Development, rehabilitation of the underground distribution system at Atlanta, Ga., electrical engineer, electrical engineer and operating manager, and, since 1923, assistant to the vice-president as well as general manager, negotiating company relations with other wire using companies on problems of inductive interference. Mr. Wills has been particularly active in the National Electric Light Association, and has served on many of its committees. He is past-chairman of the A.I.E.E. Section at Atlanta, Ga., was its delegate to the fourth national radio convention, and a member of the subcommittee on legislation in 1925. His other memberships include the Institute of Radio Engineers, the International Association of Electrical Inspectors, the executive committee of which he served for 2 years; the American Engineering Council, and the Atlanta Chamber of Commerce. Mr. Wills was also a consultant with the committee on smoke prevention.

H. L. WILLS


W. S. PETERSON

O. B. BLACKWELL

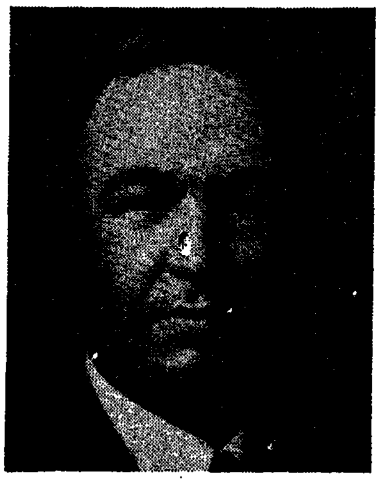
W. S. Peterson (A'23, M'29) transmission system engineer of the municipal water and power department, City of Los Angeles, Calif., has been awarded the 1931 A.I.E.E. Pacific District prize for best paper, the decision resting with his paper, "Calculation of Dynamic Power Limit of Transmission System During Three-Phase Faults." Mr Peterson was born at Anaconda, Mont. He entered upon an electrical engineering course at the University of California, Berkeley, Calif., and was graduated with the class of 1917 with his B.S. degree. He at once entered the test department of the General Electric Company at Schenectady, N. Y., remaining there until 1919, when he engaged with the Anaconda Copper Mining Company, Great Falls, Mont., for the operation and maintenance of substations. In September of 1922 Mr. Peterson started his work with the Los Angeles bureau of power and light, and in 1924 was transferred from the drafting room to the substation engineering department, his work including design of substations and writing of specifications. After a year of this work, he was advanced to research. Here his first work was the preparation of a report on the high voltage power system for the City of Los Angeles, which constituted the first step in the design of the system to receive the Colorado River power. Concurrently with this work, he was supervising the investigation of conductor movements during short circuits, the basis of a paper in joint authorship with H. J. McCracken, Jr. (A'27) and for which they received the 1927 national initial paper prize. Mr. Peterson also is serving as secretary of the technical committee of the bureau of power and light of the City of Los Angeles. His research work on the performance of insulators in dust and fog and also with regard to measurement of corona loss were carried on at the H. J. Ryan High Voltage Laboratory at Stanford University, in collaboration with Dr. J. S. Carroll (A'24) assistant professor of electrical engineering at Stanford University, and Bradley Cozzens (A'28) research engineer of the Department of Water and Power, City of Los Angeles.

O. B. Blackwell (A'08, F'17) now transmission development engineer of the American Telephone and Telegraph Company, New York, N. Y., shared in the 1931 A.I.E.E. national prize for best paper in engineering practise, for the paper which he prepared jointly with H. L. Wills (A'30) and which was entitled "Status of Joint Development and Research on Noise Frequency Induction," being an integral part of the symposium on coordination of power and telephone plant to which the prize was awarded.

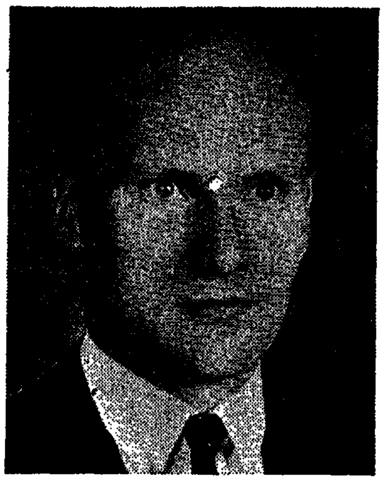
Mr. Blackwell who was born at Bourne, Mass., in 1906 received his B.S. degree from Massachusetts Institute of Technology. He at once entered the engineering department of the American Telephone and Telegraph Company, and in 1915 was placed in charge of transmission and protection, a subdivision of the department. Here he was given the supervision of some 40 technically trained men on important development and standardizing work of telephone transmission and protection circuits. By his collaborators Mr. Blackwell's work always has been recognized as uniformly of the highest grade—in fact it has won recognition for him throughout the entire telephone world. For a period of more than 7 years much of his work was looking toward the extension and betterment of telephone transmission through the use of loading coils, improved cable construction, telephone amplifiers, and similar electrical equipment. Illustrative of his work is the design of a standard transposition system for lines carrying phantom circuits, important work on the development of duplex telephone cables, and contributions of great importance to the successful use of telephone repeaters on long lines. He is a Fellow of the Institute of Radio Engineers and of The Acoustical Society of America; he also holds membership in the Machinery Club of New York City, the Manhassett Bay Yacht Club, and the North Hempstead Country Club.

H. L. Huber (M'23) engineer on foreign wire relations, American Telephone and Telegraph Company, New York, N. Y., who prepared the paper, "Status of Cooperative Work on Joint Use of Poles," in joint authorship with J. C. Martin (A'12) participates in the 1931 A.I.E.E. national prize for best paper in engineering practise, which has been awarded the symposium on coordination of power and telephone plant. Mr. Huber is a native of the state of Colorado, and a graduate of Mercersburg Academy and Cornell University. In 1913 he became plant engineering inspector for The Chesapeake and Potomac Telephone Company, Washington, D. C., designing its outside plant, preparing estimates, writing specifications, and doing construction work. In 1915 he became engineering assistant in the company's general engineering department, checking high tension line construction at crossings, and studying inductive interference and mechanical problems in connection with telephone line construction. In 1917 he was made district plant engineer in charge of laying out the outside telephone plant at Camp Meade and the Aberdeen Proving Grounds. December of that year he joined the U.S.

Signal Corps, and for the last half of 1918 as 1st lieutenant, was locating long distance telephone pole lines in France. In July 1919 he was back in the United States as division plant engineer in West Virginia for The Chesapeake and Potomac Telephone Company, and associated companies in charge of planning, estimating, and writing specifications. The next year he became engineering assistant in the company's general engineering department, which office he continued to hold until 1925 when he was made appraisal engineer. His history with the American Telephone and Telegraph Company dates from 1927.



H. L. HUBER



ERNST WEBER

L. V. BEWLEY

**Ernst Weber** (A'31) visiting professor of electrical engineering, Polytechnic Institute of Brooklyn, N. Y., has been awarded the 1931 A.I.E.E. national prize for initial paper, for his paper "Field Transients in Magnetic Systems." Doctor Weber was born at Vienna, Austria, and received his diploma as engineer from the Technical University in Vienna, April 1924; 2 years later his Ph.D. was conferred upon him by the same institution. In 1929 he earned what is termed "Privat dozent" (extraordinary professorship) at the Technical University at Berlin-Charlottenburg in the department of electrical engineering. After graduating in 1924 he was research engineer for Oesterreichische Siemens-Schuckert-Werke at Vienna in the department of electrical machine design. He then went with the Siemens-Schuckert-Werke in Berlin as research engineer in the electrical machinery department and continued there until 1930 when he came to the United States. Here he took up his present work at the Polytechnic Institute of Brooklyn in postgraduate lectures on electromagnetic theory, advanced circuit theory, and conformal mapping of high voltage problems. In September of 1931 he was made research professor of electrical engineering, still continuing with postgraduate lecturing, adding "higher mathematical analysis and its application" to his other subjects of discourse.

Doctor Weber is a member of the Viennese Institute of Electrical Engineers (1923); the Berlin Society of Applied Mathematics and Mechanics (1929) and Institute of Electrical Engineers (Germany) (1930). Only recently has become a member of the American Physical Society. He has been an abundant contributor to technical literature both here and abroad.

**L. V. Bewley** (A'27) of the power transformer department, General Electric Company, Pittsfield, Mass., has been awarded the 1931 A.I.E.E. national prize for best paper in theory and research, for his paper "Transient Oscillations in Distributed Circuits With Special Reference to Transformer Windings." Born at Republic, Wash., Mr. Bewley attended grade and high schools at Boise, Idaho. During the war, he left high school to serve as a machine gunner, spending 19 months out of the 28 he was in service, in France. Upon his return to the United States he entered the University of Washington and in 1923 received his B.S. in E.E. He joined the General Electric Company's test course, its 3-year advanced course in engineering, and the Union College G.E. cooperative course, receiving from the latter in 1927, his M.S. degree. Mr. Bewley's work has included design of induction motors, high-voltage bushings, synchronous converters, a-c. generators and motors, coupling capacitors, and power transformers. For the past few years he has been engaged with special problems of semi-theoretical and mathematical nature, and for the past 6 years in the General Electric evening courses he has taught advanced circuit theory (Maxwell, Heaviside, symmetrical components, system stability, etc.). He has contributed liberally to the Institute's literature, both with regard to technical papers and active discussion. He still holds a captaincy in the U.S. Engineers Reserve Corps.

**V. A. Hoover** (A'32) has received the 1931 A.I.E.E. Pacific District prize for initial paper, the decision being based upon the high quality of his paper entitled "Correlation of Induction Motor Design Factors." At the present time Mr. Hoover is engaged in the duties of a research assistant at the California Institute of Technology, where he is associated with Dr. S. J. Barnett, professor of physics, in special work on the nature of the elementary magnet in cobalt and nickel alloys. Under Dr. R. W. **Sorensen** (A'07, F'19) he also has been a teaching fellow in the institution's department of electrical engineering. His Ph.D degree was conferred upon him by California Institute of Technology in 1931 upon the completion of a course in electrical engineering, physics, and mathematics, the culmination of an 8-year period of work, undergraduate and graduate. Mr. Hoover has acquainted himself with the practical side of the profession also by summer work with the Southern California Edison Company, Ltd., at Los Angeles, Calif., where his duties were in connection with substations and meter testing, and by a part-time service with the U. S. Electrical Manufacturing Company of Los Angeles, as motor designer. His native city is Leadville, Colo.

**E. W. Palmrose** (A'32) who for his paper "Vacuum Tube Voltage Regulators" has received the 1931 A.I.E.E. Pacific District prize for Branch paper, was born in Finland. Upon graduation from the University of California, Berkeley, Calif., May 1931, he received his B.S. in E.E. His first practical work was as an apprentice machinist in the shops of the Hammond Lumber Company, Samoa, Calif.; this occupied him from 1925 to 1928, when after a brief interim he became connected with the Pacific Telephone and Telegraph Company, at Eureka, Calif. His position as draftsman with the Southern Pacific Golden Gate Ferries, Ltd., San Francisco, Calif., dates from late in 1929, on part time until his graduation from the university in May 1931, and full time beginning with June of that year; present activities include repairs to slips and wharves, the design of hydraulic bridge lifting machinery, parts for Diesel engines, steam condensers, and electric steering gear indicators for Diesel-electric ferries. The paper for which Mr. Palmrose was awarded the 1931 A.I.E.E. Pacific District prize for Branch paper was based upon the thesis prepared for his degree of B.S. in E.E.

**N. R. Damon** (Enrolled Student) University of Colorado, Boulder, Colo., and coauthor of the paper "New Ideas for High Voltage Circuit Breakers" shares with C. A. **Church** (Enrolled Student) in the award of the 1931 A.I.E.E. North Central District prize for Branch paper. Mr. Damon is a native of Hollenberg, Kans. He received his high school education at Laporte and Cheyenne Wells, Colo., and his technical training at the University of Colorado, from which he was graduated June 1931 with the degree of B.S. in E.E. His work at the present time is in graduate study and research at the University of Colorado, prerequisite to his master's degree in electrical engineering June 1932. Mr. Damon and Mr. Church are also fraternity brothers in Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

**J. S. Brown** (A'23, M'31) who was formerly engineer in the electrical division of the Stone and Webster Corporation, Boston, Mass., and still earlier identified with engineering projects of the firm of McClellan and Junkersfeld, Inc., and also that of Dwight P. Robinson Company, New York City, in responsible charge as electrical engineer, assistant superintendent of construction in charge of field forces, and electrical construction superintendent, now has tentatively entered upon a consulting engineering practise of his own in electrical and industrial fields, at Petersburg, Va.

E. B. Crane (A'23) previously with the Ohio Edison Company's Youngstown office as assistant engineer, effective June 1, 1932, was transferred to its central engineering department at Akron, a recently created division for the coordination and standardization in engineering design, practise, and materials.

R. H. Park (A'27), until recently an electrical engineer with the Stone and Webster Engineering Corporation, Boston, Mass., is now affiliated with the Calco Chemical Company of Bound Brook, N. J., where he is engaged in research in mathematical physics and the design of equipment. Mr. Park's work with Stone and Webster included design and operating problems in connection with various plant, structure, and equipment projects handled by that concern, particularly in connection with special analyses.

A. E. Kennelly (A'88, F'13, and past-president) professor emeritus of electrical engineering at Harvard University, Cambridge, Mass., on July 6, 1932, at a meeting in Paris, France, was chosen vice-president of the International Electrical Congress which convened there July 4-12, and at which approximately 1,300 delegates of 11 nations discussed from the angle of pure science electrical subjects of the day.

S. P. Grace (A'03, F'21) assistant vice-president of the Bell Telephone Laboratories, Inc., recently received from the University of Michigan the honorary degree of Doctor of Engineering, and from Notre Dame the honorary degree of Doctor of Laws. (The announcement in Electrical Engineering, July 1932, p. 530, did not state that the University of Michigan degree was an honorary degree.)

W. D'A. Ryan (A'02) who has been serving the General Electric Company of Schenectady, N. Y., as director of its illuminating engineering laboratory, recently was named consulting engineer of the company's lighting section.

R. A. Krasovec (A'31) whose work during the last several years has been that of chief electrician, U.S. Army Post, Mitchell Field, New York, N. Y.; electrician D. L. & W. Railroad, Hoboken, N. J., and of the New York Central Railroad, Cleveland, Ohio; chief electrician of the Lackawanna Anthracite Coal Mining Company, Vandling, Pa., and from 1929-31, electrical foreman of the Andes Copper Mining Company, Chanaral, Chile, S. A., now has joined the Corte Engineering Company of New York City, as sales engineer.

W. M. Williams (A'25) who has been serving Roth Brothers Company of Chicago, Ill., as electrical engineer, recently joined the Century Electric Company of St. Louis, Mo.

A. A. Schuhler (A'19, M'27) who recently was sales engineer for the Connecticut Telephone and Electric Corporation, at Meriden, Conn., now is chief sales engineer of Stanley and Patterson, Inc., New York, N. Y.

C. E. White (A'30) previously located at Salt Lake City, Utah, and at one time identified with the General Electric Company's general test work on electrical machinery, and with transformer engineering design, now has joined the Ohmite Manufacturing Company of Chicago, Ill., as electrical design and production engineer. Mr. White is past-chairman of the A.I.E.E. Student Branch at the University of Utah, and past-assistant secretary of the Institute's Fort Wayne Section.

W. B. Hopkins (M'20) who for the past 2 years has served the Stone and Webster Engineering Corporation of New York, N. Y., as a vice-president, engineering manager, and a director, has tendered his resignation, effective June 30, 1932.

C. L. Fortescue (A'03, F'21) who is consulting transmission engineer for the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and a frequent contributor to A.I.E.E. technical literature, in both papers and discussion, has been chosen by The Franklin Institute to receive the Elliott Cresson Medal, for "his work in presenting theory and application of symmetrical components for studying balanced and unbalanced a-c. circuits," the subject of a paper which he recently presented at a statistical meeting of The Franklin Institute, Philadelphia, Pa.

H. C. Forbes (A'25, M'30) who for the past 5 years has been research engineer in the electrical engineering department of the New York Edison Company, New York, N. Y., recently was appointed system engineer. Mr. Forbes' history with the company dates from 1924 when he joined the electrical engineering department as assistant to the chief electrical engineer.

W. B. Campbell (A'30) who for the past year or so has been serving the Delta Star Electric Company, Chicago, Ill., as assistant engineer, now is assistant curator of motive power at the Museum of Science and Industry in Chicago.

C. W. Adams (A'20) formerly manager of the carbon products division of the United States Graphite Company, of Saginaw, Mich., is now with the California Public Service Company, as its division manager at Fort Bragg, Calif.

A. C. Bates (A'31) who was research assistant at Purdue University, West Lafayette, Ind., now is identified with the University of Pennsylvania at Philadelphia, Pa., as instructor in the department of mechanical engineering.

K. W. Jarvis (A'25) who was radio engineer of the United States Radio and Television Corporation, at Marion, Ind., and who has served the Institute of Radio Engineers on several of its committees, now is assistant chief engineer of the Zenith Radio Corporation in Chicago, Ill.

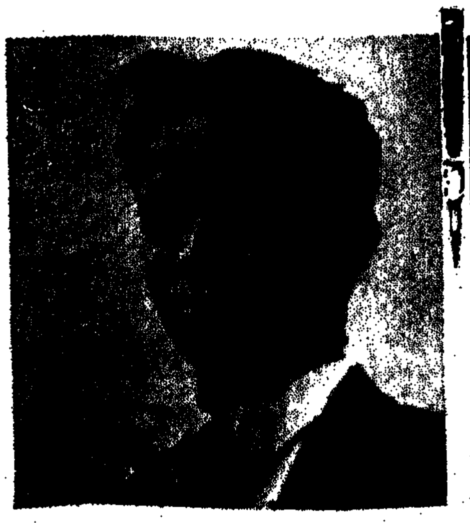
C. F. Hirshfeld (A'05) chief of Detroit Edison Company's research department and a manager of The American Society of Mechanical Engineers, recently was honored with the degree of Doctor of Engineering by Rensselaer Polytechnic Institute, Troy, N. Y.

J. L. McQuarrie (A'07, F'26) who has been serving the International Telephone and Telegraph Company, New York, N. Y., as a vice-president and chief engineer, has tendered his resignation and will retire from these connections.

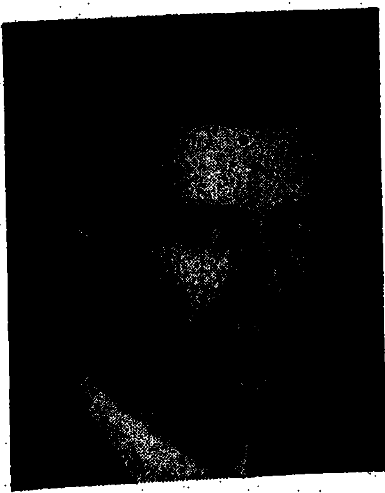
Gerard Swope (A'99, F'22) president of the General Electric Company, New York, N. Y., was given the degree of Doctor of Science recently by Washington University, at St. Louis, Mo., his native city.

F. A. Rogers (A'06, M'28) professor of physics and electrical engineering at Lewis Institute of Technology, Chicago, Ill., has been appointed dean of its engineering faculty.

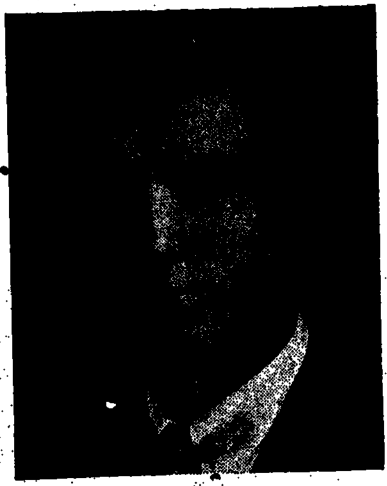
A. J. Smith (A'22, M'29) who has been serving the General Water Works and Electrical Corporation, New York, N. Y.,



V. A. HOOVER



E. W. PALMROSE



W. R. DAMON

as vice-president now has opened a consulting engineering office in Vancouver, B. C., Can.

C. A. Robinson (A'11, F'22) who prior to becoming assistant vice-president of the Chesapeake and Potomac Telephone Company was its chief engineer, recently was given the new office of general manager. His headquarters will be at Charleston, W. Va. For one year (1926–27) Mr. Robinson was chairman of the Institute's Washington (D. C.) Section, and for 2 years (1927–29) was a member of its communication committee.

Rolf Alvung (A'25) previously associated with the Standard Steel Car Company, Hammond, Ind., as an electrical engineer, now is with the Chicago Great Western Railroad, Chicago, Ill., in like capacity.

R. A. Connor (A'17) for the past year has been Pacific Coast manager of the National Electric Products, Inca manufacturing division, Los Angeles, Calif.; now he is western manager of the Phelps Dodge Copper Products Corp., Inca manufacturing division, in the same city.

P. de G. Baldwin (A'31) who last year was serving the RCA Photophone Inc., of Philadelphia, Pa., as installation and service engineer now is broadcast engineer of the WALR radio station at Zanesville, Ohio.

Newton Jackson (A'14, M'17) electrical engineer for the Virginia Public Service Company, at Charlottesville, Va., has been transferred to the company's office at Alexandria, Va.

F. I. Lawson (A'22) assistant engineer of the division of hydroelectric and transmission engineering of the Pacific Gas and Electric Company, San Francisco, Calif., recently joined that company's bureau of tests at Emeryville, Calif.

H. H. Cox (A'08, M'27) of the department of water and power, Los Angeles, Calif., has been appointed to the executive committee of the Los Angeles Electric Club for the year 1932–33.

F. J. Bartholomew (A'26) president of Electric Power Equipment, Ltd., Vancouver, B. C., is a director of the Vancouver Electric Club, for the current term of service.

J. D. Ross (A'08, F'12) has recently received his reappointment to the office of superintendent of the city light department, Seattle, Wash., a service which he already has rendered that city over an extended period during consecutive years.

S. E. Doane (A'89, F'12) consulting engineer, New York, N. Y., has received election as a vice-president of A. F. Hatch and Company, Inc., New York, N. Y., a reorganizing and refinancing body for firms in distress.

# Obituary

William Wolcott Tefft (M'26) consulting engineer of Jackson, Mich., died on June 24, 1932, at the Doctor Cowie private hospital in Ann Arbor, Mich. Mr. Tefft had for many years been prominent in the power activities of Michigan and surrounding states, and many of the outstanding developments of this region are credited to him. He was born at Milbank, S. D., in 1882, receiving his B.S. in C.E. in 1907 from the University of Michigan; in 1930 he received the honorary degree of doctor of civil engineering from the same institution. In 1910 he married Ethel L. Foote, daughter of W. A. Foote, who with his brother founded the Consumers Power Company. He began his professional career in 1902, spending summers as a rodman with surveying parties in electric railway construction, and later engaged in federal water power surveys until 1906. 1907–8 found him as resident engineer for the construction of a hydroelectric plant at Superior, Mich. His first connection with the Fargo Engineering Company, Jackson, Mich., was in 1908; here he continued as a member of the firm until 1919, having complete supervision of work on a large number of dams, many of them important plants on what is now the system of the Consumers Power Company. During this period he invented the Tefft conduit spillway which is claimed to reduce hydroelectric construction costs in some instances as much as 42 per cent. During the World War he investigated and reported to the government on water power possibilities in Michigan and Wisconsin. Continuing with offices in Jackson, he was consulting hydraulic and civil engineer for Hodenpyl, Hardy and Company between 1919 and 1924, and from this latter date until 1928 was vice-president and chief engineer of the Commonwealth Power Corporation and subsidiary companies, including the Consumers Power Company. In 1928 he entered private practise as a consulting engineer and in 1929 rejoined the Fargo Engineering Company as vice-president, in which office he continued until his death. Since 1930 he has been also president of the General Power Corporation. Mr. Tefft was the author of many technical articles, and a member of the American Society of Civil Engineers, The American Society of Mechanical Engineers, Michigan Engineering Society (director), National Electric Light Association, the American Society of Military Engineers, the American Society for the Advancement of Science, and American Men of Science. He was a member of the American committee to the World Power Conference, and was president of the board of trustees of Albion (Mich.) College. He was honored in 1929 by membership in Sigma Xi "for accomplishments in hydraulic engineering." Mr. Tefft has been active in church work. The clubs of which he was a member include the Rotary, Torch, Jackson City, Jackson Country, Jackson Gun, and the Bras Coupe Hunting and Fishing Clubs.

Robert Baird Williamson (A'02, F'12) for many years in charge of the Allis-Chalmers Manufacturing Company's division on a-c. rotating machinery, at Milwaukee, Wis., died June 26, 1932. Mr. Williamson, who was born at Smith's Falls, Ontario, Can., 59 years ago, was graduated from Cornell University, Ithaca, N. Y., in 1893. Two years of electrical construction work was followed by 2 years as chief draftsman for the Canadian General Electric Company. During the 3 years following 1897, while serving as an instructor in electrical engineering at Lehigh University, Bethlehem, Pa., the textbook "Alternating Currents" was written with Prof. W. S. Franklin as coauthor. This book for a score of years was standard in leading engineering colleges. From 1899 to 1905 Mr. Williamson served as principal of the electrical engineering department of the International Correspondence Schools. In 1905 he joined the Norwood, Ohio, plant of the Allis-Chalmers organization. His manner was quiet and unassuming and one which would inspire confidence immediately. The 27 years during which he was a member of the engineering staff of the Allis-Chalmers Manufacturing Company included a period of great expansion in the electrical industry, marked by the adoption of machinery of ever increasing size; many machines designed under Mr. Williamson's supervision have established world's records for size and efficiency. He has been a frequent contributor to A.I.E.E. literature, has served on the board of managers and as a member of the following technical committees: industrial and domestic power (1916–20); iron and steel industry (1916–20); power stations (1919–24); standards (1916–22); U.S. National committee of the International Electrotechnical Commission (1919–27); Edison Medal (1921–23); electrical machinery (1921–32); and the Lamme Medal committee (1930–32). He also served as the Institute's representative on American Engineering Council (1924–25). Mr. Williamson was a member of the honorary scientific fraternity, Sigma Xi, the Engineers Society of Milwaukee, the University Club, Westmoor Country Club, and a trustee of the Milwaukee Calvary Presbyterian Church.

Basil Condon Battye (M'21) the A.I.E.E.'s local honorary secretary for India with headquarters at Lahore, and chief engineer of the hydroelectric branch of the Punjab Public Works Department, was killed in a motor accident which occurred May 16, 1932, near Batala, district of Gurdaspur, India. Although born in Punjab, Colonel Battye received practically all of his schooling in the various preparatory institutions and colleges of Great Britain; this included a year at the Royal Military Academy at Woolwich, and a year and a half at the School of Military Engineering, at Chatham, England. In 1903 at the age of 21 he became a lieutenant in the 53rd Railway Company of Royal Engineers, the next year advancing to military assistant field engineer. In 1908 still in the English army, but working in a civilian capacity, he took what was termed "specialist training" with various firms in

England. Again returning to the strictly military field, he became officiating supervising electrical engineer of the Military Works Department, with headquarters at Simla, India. Following this he served as deputy assistant director general also at Simla military headquarters. From 1910 to 1914 his government loaned him to the Punjab Public Works Department, where, as engineer-in-charge, he designed, constructed, and operated the Simla hydroelectric and water works extensions. This work was followed by a tour of Switzerland for the purpose of inspecting all hydroelectric plants of importance in that country. November 1914 he was in command of the 21st Company, 3rd Sappers and Miners, of the Lahore Division in France; here he organized the trench searchlight service. He was wounded in the early part of 1915, but upon recuperation returned to action and became field engineer of the Lahore Division, later in that same year being made general staff officer, 3rd to 1st grade. In 1917 he became assistant engineer-in-chief, general headquarters, in charge of the forward transportation department; in 1918, chief engineer, G. H. Q. defence scheme; and later that same year, general staff officer, 1st grade, 34th Division. During the war he was 7 times mentioned in military dispatches to England and in 1916 received the D. S. O. Upon return to civilian life in 1919 he became engineer-in-charge of the Sutlej River hydroelectric project, then under investigation, with surveys to complete and design and estimates to prepare. His connection with the Punjab public works department took him out upon many missions of design and construction. It was while on a company errand that he was fatally injured in a motor crash. He was an associate member of the British Institution of Civil Engineers and the Institution of Electrical Engineers, and also of the American Society of Civil Engineers.

Archibald Johnson Robertson (A'16) substation manager for the Mt. Whitney division of the Southern California Edison Company, Ltd., at Visalia, Calif., died suddenly June 13, 1932, in that city. Born in Cleveland, Ga., September 19, 1876, he spent the period 1894–98 in attendance at Georgia School of Technology at Atlanta. His first commercial work was with the Fulton Bag and Cotton Mills in that city; but he remained with these interests for less than a year and in 1899 joined the Hardy Tyne Manufacturing Company at Birmingham, Ala. Later in the same year he became operator of various hydroelectric plants of the Mt. Whitney Power and Electric Company (subsequently a unit of the Edison system). His affiliation with this company continued unbroken up to the time of his death.

Henry Lyles Zabriskie (A'03) who has been serving the Diehl Manufacturing Company, of Elizabethport, N. J., as chief engineer, died the evening of July 10, 1932. He was born in New Baltimore, N. Y., January 26, 1877; from Cornell University, in 1898, he won his degree of M.E. in E.E. This, however, was 2 years subsequent to his first practical professional work when he served the Excelsior Electric Company of Brooklyn, N. Y., in its drafting and testing departments. For a short period he was with the Fort Wayne Electric Company (Indiana), as assistant to the electrical engineer, and upon leaving this company in 1899, he became assistant electrical engineer for the Siemens and Halske Electric Company, of Chicago, Ill. Here he remained until late in the year 1900, when he joined the New York Transportation Company, New York, N. Y., first in its electrical engineering department, and later becoming treasurer. His record with the Diehl Manufacturing Company covers a period of more than 25 years, always in the office of chief engineer. He was a member of the Institute's electrical machinery committee 1926–27, 1928–31.

Richmond Talbot (A'02 and Life Member) who has been a member of the firm of Sanderson and Porter, an engineering concern of New York City, died at his home in Tuxedo, N. Y., May 26, 1932. He was 59 years of age and a native of New York City. After a primary education obtained in the Cutler private school of New York City, Mr. Talbot attended the Philips Exeter Academy, later graduating from Harvard University with the class of 1896. For about a year thereafter he was associated with the Marsh Plate Glass Company of Pittsburgh, Pa.; then he returned to New York City to become a member of the firm of Sanderson and Porter, at that time active in electric lighting and railway design, construction, and operation; hydraulic development, and transmission. In 1899 in addition to his duties with Sanderson and Porter, he took over the general managership of the Tuxedo Electric Light Company, at Tuxedo, N. Y., his place of residence. In his Sanderson and Porter affiliation he was associated with many important public utility and industrial activities organized and built up by his firm, and with their management and operation. His social clubs included the Union, Racquet and Tennis, New York Yacht, City Midday, Harvard (N. Y.), St. Nicholas Society, Tuxedo, and the Harvard Club of Boston.

Frank Haye (A'31) electrical mechanic of the Industrial Electric Motor and Tool Company, Inc., New York, N. Y., died suddenly June 9, 1932, in New York, N. Y., of heart failure. He was born in Tettnang, Germany, March 8, 1903. He attended a trade school, studying electrical engineering, in Munich, becoming an electrical mechanic. From 1917 to 1920 he served an apprenticeship in his native town; then early in 1921 he engaged as mechanic with a firm in Friedrichshafen, Germany. This experience which was of short duration was followed by 2 years as electrician helper for a number of local business interests in Munich, Germany. The first of the year 1923 found him engaged as electrical mechanic for Mittlere Jsar A. G., Munich, where he remained until the fall of 1924 when he became salesman of tools, for commercial interests at Koenigsberg e. P. The following fall he went to Stockholm, Sweden, as electrician for Wenlenhoffs Elektriska Aktiebolag, serving in this capacity with this and another firm until March 1927 when he came to the United States and engaged with the company with which he was connected at the time of his death.

# Local Meetings

## District No. 6 Holds Annual Student Conference

In attendance at the sixth annual conference of student branches held by the Institute's North Central District (No. 6) April 15 and 16, 1932, at the University of Denver, Denver, Colo., were 73 members, delegates and other interested parties, most of whom took part in the many active discussions. Two sessions of the conference were held, one Friday afternoon, and one Saturday morning, both presided over by District Vice-President P. H. Patton of Omaha, Neb. Friday evening, April 15, the delegates to the conference were guests of the Denver Section at dinner, following which Dr. Charles A. Lory, president of the Colorado State Agricultural College, Ft. Collins, addressed the group on the subject of "Rural Electrification," a subject of local and timely interest which aroused extensive discussion. At the Friday afternoon session, the following papers were presented:

Detailed Report on the 1931 Annual Summer Convention, by H. F. Rice, student counselor, University of North Dakota Branch, and M. S. Coover, secretary District No. 6.

Observations on the Success and Failure of Engineering Graduates, by R. B. Bonney, educational director, Mountain States Telephone and Telegraph Company, Denver, and A. H. Heitzler, superintendent, electric department, Public Service Company of Colorado, Denver (two papers).

The Importance of a good Command of English in the Life of the Engineer, by P. H. Patton, District vice-president.

What Should Be the Place of the Engineer in Present Day Life?, by W. C. DuVall, student counselor, University of Colorado Branch.

The Saturday morning session was opened by an address by Dr. W. D. Engle, vice-chancellor of the University of Denver, who voiced the official welcome to the delegates to the conference. Presented at the

Saturday morning session were the following papers.

What Should Be the Place of the Engineer in Present Day Life? by H. S. Rush, student counselor, North Dakota Agricultural College Branch, and W. M. Ely, chairman, University of Nebraska Branch (two papers).

How Can the Branch Aid in Developing Personality and Leadership Among Its Members? by C. W. Caldwell, counselor, University of South Dakota Branch, F. W. Cooper, chairman, University of Colorado Branch, and L. J. Schwehr, chairman, North Dakota Agricultural College Branch (three papers).

How Can the Branch Aid the High School Senior and the College Freshman to Determine His Adaptability for an Engineering Career? by L. C. Trussler, chairman, University of Denver Branch, A. J. Redmann, chairman, University of North Dakota Branch, and H. L. Fry, chairman, South Dakota State School of Mines Branch (three papers).

Should Engineering Schools Modify Their Curricula to Better Meet Present Day Economic Conditions? by G. H. Sechrist, counselor, University of Wyoming Branch, and J. O. Kammerman, counselor, South Dakota State School of Mines Branch (two papers).

To What Extent Should Students Be Urged to Become Members of the A.I.E.E.? by F. W. Norris, counselor, University of Nebraska Branch, L. Johnson, chairman, University of South Dakota Branch, and N. H. Sanders, chairman, University of Wyoming Branch (three papers).

The conference took action on the question of the seventh annual District conference, assigning it to the South Dakota State School of Mines, Rapid City, S. Dak., for the spring of 1933. Conference action also included the election of Prof. H. S. Rush, counselor of the North Dakota Agricultural College Branch, as chairman of the committee on student activities for the North Central District, to succeed Prof. H. F. Rice, counselor of the University of North Dakota. Professor Rush attended the annual summer convention at Cleveland in June 1932 as the counselor delegate from District No. 6.

Analysis of the attendance of the District conference is as follows:

| | |
|---|---|
| District officers | 2 |
| Student counselors | 8 |
| Branch chairmen | 8 |
| Students, Colo. State Teachers College | 3 |
| Students, Univ. of Denver | 4 |
| Students, Univ. of Colo. | 4 |
| Mountain States Tel. & Tel. Co. | 8 |
| Public Service Co. of Colo. | 16 |
| General Electric Co. | 4 |
| Colo. Agricultural College | 2 |
| Univ. of Colo. | 3 |
| Univ. of Denver | 2 |
| Consulting engineers and others | 9 |
| Total | 73 |

## Past Section Meetings

**Atlanta**

Functions of a Public Service Commission, by James A. Perry, Georgia Pub. Serv. Commission. June 6. Att. 230.

**Boston**

Annual meeting. Election of officers: F. D. Hallock, chmn.; W. H. Timbie, vice-chmn.; G. J. Crowdes, secy.-treas. May 17. Att. 120.

**Cincinnati**

Joint meeting with the Univ. of Cincinnati Branch. The following papers presented by students: Design and Construction of a Laboratory Arc Furnace, by E. J. Emmerling; Measurement of Modulation, by J. Epstein; Measurement of Radiation, by C. L. Ramsey; Constant Radio Frequency, by A. C. Hereweh. May 12. Att. 140.

**Columbus**

Astronomy and Human Affairs, by Prof. H. T. Stetson, Ohio Wesleyan Univ. Election of officers: K. Y. Tang, chmn.; Roy Mallory, vice-chmn.; H. L. Willson, secy.-treas. June 3. Att. 30.

**Detroit-Ann Arbor**

Election of officers: O. E. Hauser, chmn.; J. R. North, vice-chmn.; R. Foulkrod, secy.-treas. Golf and dinner. June 18. Att. 43.

**Houston**

Election of officers: James B. Arthur, chmn.; P. H. Robinson, secy.-treas. Dinner. May 31. Att. 81.

**Ithaca**

Teletypewriter Systems, by B. K. Boyce, N. Y. Tel. Co. April 22. Att. 160.

Election of officers: W. E. Meserve, chmn.; B. K. Northrop, secy.-treas. June 3.

**Louisville**

Business and recreational meeting. Election of officers: C. M. Ewing, chmn.; L. O. Adams, secy.-treas. June 17. Att. 72.

**Memphis**

Inspection trip through the Memphis Pwr. and Lt. Co. June 21. Att. 55.

**Mexico**

Outlook of Railroad Electrification in Mexico, by P. Gomez Pena, Natl. Rys. of Mexico. Dinner. June 16. Att. 36.

**Minnesota**

Annual dinner dance. Election of officers: H. J. Pierce, chmn.; E. H. Hagensick, vice-chmn.; R. R. Herrmann, secy.-treas. June 3. Att. 88.

**San Antonio**

Organization and Cooperation vs. Individual Ability, by M. C. Johnson, J. C. Penny Co. Dinner. May 28. Att. 57.

**San Francisco**

Adventures in Science, by Ellis L. Manning, Genl. Elec. Co. Dinner. May 31. Att. 1150.

**Sharon**

Ultra Violet and Its Application, by G. W. Keown, Westinghouse Lamp Co. Film—"Hydro Electric Power Development in the New South." June 14. Att. 98.

**Spokane**

History of the Electrical Development of the Inland Empire, by John B. Fisken, Washington Water Pwr. Co. May 26. Att. 14.

**Toledo**

Research as a Tool of Industry, by Dr. W. E. Wickenden, Case Sch. of Applied Science. April 5. Att. 700.

Problems in Designing of Large Alternating Current Generators, by S. H. Mortensen, Allis-Chalmers Mfg. Co. Illus. April 15. Att. 28.

Application of Electricity in Industry, by Ralph Paxton, Toledo Edison Co. May 20. Att. 30.

Modern Engineering Achievements, by C. L. Proctor, Toledo Edison Co.; Humaneering, by S. K. Mahon, Toledo Edison Co. Election of officers: I. H. Heitkamp, chmn.; E. H. Howell, vice-chmn.; W. M. Campbell, secy.-treas. June 15. Att. 28.

**Urbana**

Election of officers: E. A. Reid, chmn.; H. N. Hayward, vice-chmn.; L. L. Smith, secy. May 16. Att. 14.

**Vancouver**

Annual meeting. May 21. Att. 23.

Election of officers: G. R. Wright, chmn.; L. B. Stacey, vice-chmn.; D. M. Johnstone, secy. June 6. Att. 21.

**Washington**

Cleveland-Emerson Dial Project, by J. A. Remon, Chesapeake & Potomac Tel. Co. Dinner. April 12. Att. 160.

Functions and Operation of Meter Department, by W. H. Fellows, Potomac Elec. Pwr. Co. Election of officers: Prof. T. J. MacKavanagh, chmn.; Roland Whitehurst, vice-chmn.; E. T. Walker, secy.-treas. Dinner. May 10. Att. 75.

## Past Branch Meetings

**Armour Institute of Technology**

Election of officers: H. Rychlick, chmn.; R. Snelling, vice-chmn.; H. Schwennesen, secy.; E. Dumser, treas. June 10. Att. 41.

**Carnegie Institute of Technology**

Electrical Achievements of 1931, by W. B. Spellmire, Genl. Elec. Co.; Experiences in the General Electric Student Test Course, by H. S. Young, Jr., Genl. Elec. Co. May 27. Att. 39.

**Michigan College of Mining and Technology**

Election of officers: Jerome Williams, chmn.; Leon Messenger, vice-chmn.; Fredrick Plaga, secy.; Robert Simpkins, treas. June 1. Att. 12.

**Milwaukee School of Engineering**

Progress of Aviation in the United States, by C. E. Mayhue, Kohler Aviation Corp. Election of officers: Gale Young, chmn.; Wm. Kettenacker, vice-chmn.; Roy Christianson, secy.; Anthony Flout, treas. June 8. Att. 102.

**University of Minnesota**

Election of officers: Paul Erickson, chmn.; Arvid Turnquist, secy.-treas. May 24. Att. 36.

**University of New Hampshire**

Election of officers: Roger Hunt, chmn.; Leslie Huse, vice-chmn.; Philip Thomas, secy. April 23. Att. 24.

Thyratron Tubes, by L. A. Barker, student; Characteristics of a Motor With a Centrifugal Pump Directly Connected to the Motor, by P. A. Rolfe, student; An Experiment on Concatenation, by V. T. Swain, student. May 14. Att. 21.

Transformer Harmonics, by H. J. Joyal, student; Electrical Transients, by H. Wood, student; Magnetic Brakes, by B. Booth, student. May 21. Att. 19.

**College of the City of New York**

Election of officers: John Ragazzini, chmn.; Charles Grossfeld, vice-chmn.; Richard Brill, secy.; G. B. Criss, treas. May 19. Att. 21.

**University of North Dakota**

Business meeting. May 25.

**Pratt Institute**

Shot-Gun Fuses, by A. F. Bruder, student. May 26. Att. 20.

Election of officers: Galen Allison, chmn.; Raymond Farrell, vice-chmn.; Allan Tiffany, secy.; George Stringer, treas. May 27. Att. 30.

**Stanford University**

The Five Year Plan in Relation to Engineering, by P. M. Narbutovskih, student. Election of officers: George W. Dunlap, chmn.; G. E. J. Jamart, vice-chmn.; L. J. Lewis, secy.-treas. June 1.

**Texas Technological College**

Population Forecast, by Arthur Waghorn presented by J. P. Conner, students. Film—"Speeding Up Our Deep Sea Cables." Election of officers: J. P. Conner, pres.; Walter Cox, vice-pres.; S. A. Cousins, secy.-treas. May 18. Att. 17.

**University of Washington**

Milwaukee Electrification, by R. Beeuwkes, Chicago, Milwaukee, and St. Paul Ry. Co. May 26. Att. 44.

**University of Wisconsin**

Calculation of Magnetic Flux Density and Force Between Bus Bars, by W. E. Wyss, student. March 8. Att. 23.

Prospecting in Science, by M. W. Hanks, Hankscraft Co. April 20. Att. 65.

The Use of Models at Short Wave Lengths in Antenna Investigations, by G. H. Brown and R. King, students. Election of officers: W. E. Wyss, chmn.; H. H. Kieckhefer, vice-chmn.; L. A. Leifer, secy.-treas. May 18. Att. 26.

# Employment Notes

## Of the Engineering Societies Employment Service

## Positions Open

EXEC. DESIGNING ENGR. for oil switch division. Must be fully trained E.E. thoroughly experienced in the modern design and construction of high tension overhead equipment, especially oil switches. Must have executive ability and speak German fluently. Apply by letter stating complete information as to age, education, experience, references, salary, etc. Location, Europe. W-3754-CS.

## Men Available

### Construction

ASSOC. A.I.E.E., B.S. IN E.E., 33, single, 10 yr. experience in construction with contractor, 1½ yr. instructor in high school, 2 yr. field engr. during a survey with utility. C-8633.

GRAD. E.E., 29, 5 yr. supervisory construction, design, estimating and field engg. experience on super-power plants and substations; 4 yr. industrial pwr. plant operation, elec. construction and maintenance experience; ry. electrification construction experience. C-4428.

PRACTICAL ELEC. CONSTRUCTION CHIEF, 32, single, 14 yr. experience in construction and also maintenance work. Last 4 yr. in Latin-America. Can speak Spanish and German fairly well. Available immediately. Location, immaterial. C-2101.

### Design and Development

GRAD. E.E., M.I.T., 1923, 31, single. Design of steam and hydro gen. stations. Substations, pwr. transmission lines and industrial installations. Available immediately. Location, immaterial. D-1008.

E.E. GRAD., 29, single, 2 yr. additional study in accounting, 2 yr. experience on elec. wiring of bldgs., 5 yrs. experience on elec. and mech. design, development, and lab. work on fans and small motors with leading mfr. Also experience in drafting and commercial engg. New England preferred. D-580.

E.E. GRAD., 29, single, 5 yr. experience including 6 months testing a-c., d-c. machines, 4½ yrs. design 5 to 2,000 hp. a-c. and d-c. motors for industrial and special applications. Thoroughly familiar with motor quotations, estimates and applications. Desires position with utility, mfg. or construction firm. Location, U.S. Available immediately. D-944.

ELEC.-MECH. ENGR., 30, married, college grad. with unusual abilities for elec. relay circuits (autom. teleph., control, alarm systems, signaling), resourceful mech. designer on small apparatus, 5 yr. engg. experience. Available immediately. Location, immaterial. C-8373.

EMPLOYERS—Should you require a designer or operator for elec. transmission and distribution or a pwr. salesman, permit me to qualify. B.S. in E.E. and 7 yr. diversified utility experience. B-9709.

### Executives

B.S. AND E.E., 20 yr. experience; test, instructor 2 yr., line supt., constr. engr. large mining co., elec. engr. lighting and pwr. co.; engr. for utility holding co. Experience covers constr., design stations, substations trans., dist. lines, P.F. correction, line calculations, economic studies, system planning. Will go anywhere and accept any salary. D-1064.

GRAD. E.E., 1927, single, 26. Experience: 18 months cable development, 2 yr. installation and service engr. on talking picture theater equip. including foreign service. Additional education 1 yr. genl. course economics, etc., Univ. of London. Position desired offering experience with economic problems or personnel relationships. D-1159.

EXEC. ENGR., Scandinavian, 43, Amer., with 20 yr. experience in design and research of pwr. stations, transmission lines, transformers, and oil circuit breakers, desires position in U.S. or abroad for pwr. or mfg. co. Speaks German and Scandinavian fluently and is thoroughly familiar with Amer. and European Mfg. methods. D-1176.

EXEC. ENGR., mech. and elec., 43, Amer., col. grad. Broad experience in designing, bldg. and operating large industrial pwr. plants. Have exceptional qualifications for rapid, thorough and economical engg. of such projects and the ability to obtain maximum value for the entire investment. D-986.

E.E. GRAD., 12 yr. experience in distribution circuit work, design, testing, etc., and having a completed training in law, desires a position for which experience will qualify. D-1177.

DISTRIBUTION ENGR., tech. grad., 30, married, 8 yr. experience in design, construction and operation of rural and urban distribution systems and evaluation of systems. Best of references. Available at once. C-4247.

ELEC. AND MECH. ENGR., 36, exec., 12 yr. experience in design, construction, development, investigations of pwr. projects and systems expansion for utilities and industrials in the states and abroad. Speaks Spanish and Portugese. D-857.

EXEC. ASST. to pres. or vice-pres. of holding or large operating utility. Twenty yr. experience in construction, engg. and operation, transmission, distribution, city and rural substations, pwr. stations, appraisals, rates, right-of-way, interconnections and reports. East preferred, not essential. D-1246.

### Instruction

E.E. GRAD., 1929. G.E. test experience including work in radio and vacuum tube engg. dept.; and with all types of elec. machy. Received M.S. June 1932. Desires teaching or engg. opportunity. D-1036.

E.E. GRAD., 25, married, 4 yr. exceptional tech. experience, some very successful teaching experience. Desires position as instructor in E.E. subjects, mathematics or physics with opportunity of taking graduate work. C-4303.

E.E., Bachelors and Professional degrees, have held responsible teaching position in state institution and have had research experience. Location is not a material consideration. B-7263.

MEMBER, B.SC. IN E.E. Experience: lecturer; asst. prof. and prof. in charge of E.E. dept. of prominent univ., followed by practical design, latterly in charge of a-c. design for well-known mfr. of elec. machy. Desires position teaching or one which demands thorough knowledge of motors. D-1213.

### Junior Engineers

E.E. GRAD., 1932, Mich. State Col., 23, singl. Desires engg. work, but will consider anything. Experience in drafting and telephone work. Available at once. Location in Middle West preferred, others considered. D-1236.

E.E. GRAD., 1931, single, 24. Special training in radio, sound apparatus, and photoelectric cells. Desires position in the radio or electroacoustical field or teaching opportunity. Location, immaterial. Available immediately. D-1240.

E.E. GRAD., B.S. IN E.E., Univ. of Ill., 1932, 23, single. Ten months long distance telephone test A. T. & T.; 2 months motion picture sound equipment. Familiar with vacuum tubes and their applications. Available at once. Location, immaterial. D-1108.

JUNIOR ENGR., 1932 grad. of a cooperative tech. col. Has had experience with illumination design; radio manufacture and service. Location, immaterial. D-1109.

GRAD. IN E.E., 1932, 21, desires position immediately, strong physique. Will take anything. Location, immaterial. D-1010.

B.S. in E.E., 1932; single. Fourteen months G.E. test between junior and senior yr. Test records available. Excellent scholastic record. Tech. type: developed thesis; 9 contributions presented at A.I.E.E. Good personality and initiative. Location and salary immaterial. D-1127.

1931 GRAD., Cornell Univ. and Pratt Inst. in Brooklyn. Slight experience with vacuum tubes and resistors. Desires work in radio television, communication, or lines allied to that industry. Available on short notice. Location, immaterial. C-5636.

EXPERIENCED 1932 GRAD., 24, single. Vacuum tubes, photoelectric cells, circuits, research, design, and manufacture. Elec. measurements, especially with cathode ray oscillograph. Experienced in application of elec. methods to mech. engg. problems. Full or part time work. Location preferred, vicinity of New York City. Available after Aug. 15. D-616.

B.S. IN E.E., Carnegie Inst. of Tech., 1932, 5 yr. in radio work and repairing household appliances. Salary immaterial at start. Location, immaterial. Available at once. D-1140.

E.E., 22, single, good references; desires work in generation or transmission of elec. pwr. Satisfied with small salary in order to gain knowledge in field. Has had 2 yr. experience as cooperative student in manufacture of motors and generators. Can locate anywhere. D-159.

E.E. GRAD., 1932, 22, married. Experience in solution of distribution network problems. Desires position in any field of engg. with opportunity for advancement. Salary and location, secondary. Good scholastic record. D-1160.

GRAD. E.E., Rensselaer Poly. Inst., 1932, 23, single. One summer's work on relay squad of N. J. Pub. Serv. Desires position in any E.E. field, preferably illuminating. Available at once. D-1158.

E.E. GRAD., 1930, Columbia, 6 yr. course, 25, single, 1½ yr. with Paramount Publix Theatre Construction. Knowledge sound and projection equip., drafting, supervision of construction and layout; instruments, foundry, and pattern shop methods. Desires connection, any engg. capacity. Available immediately. Present location, New York but willing to go anywhere. C-7239.

1932 GRAD., E.E., B.S., from Ohio Northern Univ., 23, single and excellent physical condition. Best of character standing and willing to work hard, starting at the bottom and working up. Desires any position that will pay a living wage. Location immaterial and available immediately. D-1167.

E.E. GRAD., 1931, 25 single, cooperative col.; 12 months experience as asst. in production lab. of a battery mfg. concern. Six months experience as a genl. draftsman. Speaking and reading knowledge of German. Desires position with future.

## ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
San Francisco

205 West Wacker Drive
Chicago

31 West 39th St.
New York

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

**Men Available.**—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

**Opportunities.**—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

**Voluntary Contributions.**—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

**Answers to Announcements.**—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

Location and salary secondary. Available immediately. D-534.

GRAD. E.E., 26, single. Two yr. experience in maintenance, test, and distribution with utility. One yr. drafting and mech. design. Two yr. elec. control sales. Available on short notice. Eastern location preferred. C-6445.

E.E. GRAD., Master's deg., V.P.I., '30, 23, married. One summer in relay dept. pwr. co., 1 yr. teach. fellow, 1 yr. teach. elec. in H.S. Six summers certified electrician. Needs engg. position in utility or industrial concern, or instructor in physics, mathematics or E.E. D-1198.

E.E. GRAD., Yale, B.S., Cum Laude, 1931. M.S. in E.E., 1932, 22, single. Desires experience with utility or industrial concern. Available immediately. Location anywhere in U.S. Northeast preferred. D-1212.

RECENT GRAD., B.S. IN E.E., 23, Newark Col. of Engg., cooperative training with Diehl Mfg. Co. Desires opportunity with future in production or sales. Previous experience in organization. Prefers location in New York metropolitan area. Available at once. D-1137.

E.E. GRAD., cooperative course, Drexel Inst., B.S., 1931. M.S., M.I.T., 1932, 23, single. Two yr. experience in plant dept. of Bell Tel. Co. of Pa. Desires engg. or teaching position. Location in East preferred. Available immediately. References upon request. D-1087.

B.E.E., Northeastern Univ., 1932. Experienced in utilities meter and station repair dept. Good references. Available at once. Location, immaterial. D-1211.

E.E. GRAD., 1932, 24, single. B.S. in E.E. from well known engg. school. Good scholastic record. Four yr. mfg. experience includes timekeeping, cost work, maintenance and assembly. Desires position with opportunity for advancement with utility, engg., or mfg. firm. Location preferred, Ohio-Pa. vicinity, but will consider others. D-908.

E.E., married, E.E., M.E. Twenty-two yr. experience, designing, construction pwr. plants, substations, transmission, distribution systems, and industrial plants, three yr. charge purchasing engg. equip., foreign interests. Three yr. exec. experience, charge engg. dept. large utility syndicate. English, German, Russian, Armenian, Turkish languages. Available immediately. D-84.

1932 GRAD., Univ. of Ala., 21, single, desires position in any engg. field. Languages: English, German, and Polish. Available immediately. Location, immaterial. D-1166.

E.E., grad. 1928, 28, married. 3½ yr. Westinghouse test course. Good experience on motors and control apparatus; also some civil engg. and supervisory experience. Not afraid of responsibility. Desires a position with future. Location, immaterial. C-9568.

E.E. GRAD., 1932, cooperative col. One yr. with Weston Instrument Co. in various dept. 1 yr. genl. maintenance work. Desires position with any mfg. or engg. concern. Location, immaterial. D-1112.

B.S. in E.E. from Worcester Poly. Inst., 1932, 24, single. Desires engg. work of any nature. With construction company for 4 summers. Location, immaterial. Very good references can be furnished. D-1227.

CORNELL E.E. 1932, A.B. 1930, 23, single, communications option, experienced in design and operation of radio and public address equip. One summer in Bell Tel. Lab. Two summers elec. construction on substations and plant additions. Can write clear concise letters and reports. Salary secondary, East preferred. Available October 1. D-1221.

B.S. 1930, E.E. 1931 from Univ. of So. Car., 23, single. Six months experience with South Carolina Pwr. Rate Investigating Committee. Able and willing to do practically any type of engineering work. Available immediately. Location, immaterial. Can give best of recommendations. D-595.

ENG. GRAD., R.P.I., 1932, E.E. Desires position, preferably pwr. or communications. Location, immaterial. Some experience in drafting. Graduation thesis design of central station. D-1245.

**Maintenance & Operation**

E.E., B.S. in E.E., 1930, Univ. of Idaho, 24, married. Two yr. with Bell Tel. Lab. in trial installation of new circuits and equip., chiefly telephone equip. for broadcast networks and transatlantic communication. Desires work in an industry or utility with opportunity for advancement. Location, U.S.A. Available at once. D-1001.

E.E. GRAD., 1928, Tri-State Col., 27, single, 3½ yr. engg. experience with utility in design, layout, and detailing of pwr. plant, substations and distribution lines. Desires connection in engg. or operating capacity, in steam pwr. plant. Location, immaterial. Now available. D-89.

RADIO ENGR.-OPERATOR. Fifteen yr. commercial experience; last 8 in broadcast stations including 3 yr. with KDKA. Now with station in metropolitan area. Would like connection with small Southern station. Able to design and construct latest type radio equipment, also serve as operator (licensed). D-1237.

TRANSFORMER ENGR., experienced, installation, care, maintenance, design large pwr. transformers. Nineteen yr. with mfg. transformer where work included preparation of instructions for transformer, erection and examination of failures and determining probable cause. Would be valuable to concerns with number of transformers under their supervision in seeing transformers are properly used, attended, operation. Married. B-199.

RY. E. E., 43, specialist on heavy elec. traction installation, practical operation, and maintenance. E.E. grad., 8 yr. with G. E. Co. in testing, engg., and sales work. 12 yr. in installation, operation, and maintenance of electrification of the C.M.St.P.&P. RR. Contributor to tech. magazines on elec. traction subjects. References and other information furnished on request. Available at present. D-1263.

**Research**

E.E., 1930, with 2 yr. research work, post graduate study and excellent scholastic record, desires tech. work, preferably mathematical. Location, Northeastern U.S. preferred, but will consider others. D-1183.

E.E. GRAD., 23, Sc.M., M.I.T., Harvard 28; Sc.D., M.I.T., June '32; single, 38; 9 yr. practical experience pwr., business and communication engg.; 2 yr. testing course. Recently made valuable contribution to knowledge net work synthesis. Speaks Swedish, English, German. Reading knowledge French. Desires position, well-known organization preferably communication engg. Available July 15. D-747.

GRAD., Yale 1930, B.S. in E.E., Tau Beta Pi, Assoc., Sigma Xi. Test experience, regulators, motors, industrial control, rectifiers, transformers, photoelectric cells, short circuit lab., work's lab. on insulation, and development work, research lab. Desires employment leading to exec. position. New England preferred. D-1192.

GRAD. E.E., Univ. of Toronto, Canada, 1929. Practical transformer construction experience drafting; 6 mo. test course, Can. Westinghouse; 3 yr. with large U.S.A. alloy co. in supervisory capacity on elec. furnace process and plant operation. Location, immaterial. Available immediately. D-1226.

DEVELOPMENT ENGR., 26, single, E.E. and M.S., high scholastic rating, 3 yr. G.E., research, test and field engg., 2 yr. development of pwr. plant equip. for telephone offices. Location, immaterial. Best of references. Available now. D-1219.

B.S. in E.E. and M.A. in Physics, 25. Three yr. experience at leading industrial lab. in research on vacuum tubes and associated circuits. Desires development work on radio, communication or sound equip., research or teaching E.E. and physics. D-1233.

MECH. and E.E.: Development, research. Elec. motor control, hoisting and conveying, mech. and elec. tests of materials, metallurgy, metallography X-ray analysis. C-6994.

# Membership

## Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the acting national secretary before Aug. 31, 1932.

L. A. Cantin, E. E. Student, Angola, Ind.
Cater, F. L., (Member) W. R. Grace & Co., N. Y.
City.
Crooks, C. L., Pub. Serv. Dept., Glendale, Calif.
Frey, J. C., Hatzel & Buehler, Inc., N. Y. City.
Hartong, H. H., 100 Haven Ave., N. Y. City.
Hildebrandt, C. H., N. Y. Central R. R. Co.,
Weehawken, N. J.
Hobson, L. S., Genl. Elec. Co., Phila., Pa.
Kallenbach, G. K., N. Y. Pwr. & Lt. Corp., Pleasant
Valley, N. Y.
Kaul, R. D., Garrison Fire Detecting System Inc.,
N. Y. City.
Miller, R. D., (Member) The Pacific Tel. & Tel.
Co., Portland, Oregon.
Rose, M. C., C. & P. Telephone Co. of B. C.,
Baltimore, Md.
Schnyder A. P. (Member) c/o Geo. F. Hardy,
Construction Engr., N. Y. City.
Schleicher, M., 11 Cottage Place, White Plains,
N. Y.
Simm, S. G., c/o Clyde R. Place, Engr., 420 Lex-
ington Ave., N. Y. City.
Sullivan, A. H. (Member) Cincinnati Union
Terminal Co., Ohio.
15 Domestic

### Foreign

Banton, F. B., (Member) Cia Colombiana de
Electricidad, Barranquilla, Colombia, S. A.
Beljavsky, A. G. (Member) North-Caucas Inst. of
Energetics, Novocherkassk, U.S.S.R.
Bryant, A., Kenya & Uganda Govts., Nairobi,
Kenya Colony, E. Africa.
Chan, S., 33 Wan Tsai Rd., Hong Kong, China.
Gibbes, Gerald B., Government Electricity Depart-
ment, St. George's, Grenada, B.W.I.
Headland, H., Pub. Wks. Dept., Waitaki Hydro,
South Island, N. Z.
Hickey, M. G., Hackbridge Elec. Construction Co.,
Hersham, Walton-on-Thames, Surrey, Eng.
Sawhney, B., Assoc. Electrical Industries, Lahore
India.
Thampan, K. C., Pykara Construction Wks., Glen
Morgan P. O., The Nilgiris, So. India.
Verma, R. P., Gaya Engg. & Elec. Pwr. Sup. Co.,
Ltd., Gaya, India.
10 Foreign

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Anaya, Mexico City, Mex.
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Bugg, Vernon, 736 Transp. Bldg., Washington,
D. C.
Callen, R. J., Brunswick Recording Lab., 799 7th
Ave., N. Y. City.
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Darby, Pa.
Heffter, Juan, Calle Borges 958, Olivos, Arg. Rep.,
S. Am.
Iwe, Halfdan G., 229 Ovington Ave., Bklyn., N. Y.
Morita, Kadzuo, c/o Chosen Hydro-Elec. Co.,
Kankyo-Nando, Korea, Japan.
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Van Ness, L. G., 2105–6 Sterick Bldg., Memphis,
Tenn.
Vere, Fernand, Union Telefonica, Calle Defensa
No. 143, Buenos Aires, Arg., S. Am.
Vetri, L., Western Elec. Co., Inc., 100 Central Ave.,
Kearny, N. J.
Wiley, Walter S., 200 Fackney St., Carmi, Ill.

# Engineering Literature

## New Books
## in the Societies Library

Among the new books received at the Engineering Societies Library, New York, during June are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

INTERNATIONAL UNEMPLOYMENT, a Study of Fluctuations in Employment and Unemployment in Several Countries, 1910–1930. M. L. Fleddérus, ed. Hague, Holland, and New York, International Industrial Relations Institute, 1932. 496 p., 10x7 in., cloth, $2.50.—For the 1931 Social Economic Congress at The Hague various nation's economists were asked to prepare studies on employment fluctuations to picture the recurrence of unemployment during the last 2 decades. The studies presented in this volume factually show conditions in Australia, Canada, China, Germany, France, Great Britain, the United States, and Russia.

LOAD CURVES AND POWER INDEXES IN THE OPERATION OF ELEC. STATIONS. (In Russian.) By A. K. Darmanchev. 1931, Moscow and Leningrad, Gosudarstvennoe Nauchno-Tekhnicheskoe Izdatelvstvo. 119 p., 9x6 in., paper, no price given.—According to Mr. Darmanchev, load curves usually are discussed solely in relation to power plant layout. In the present book they are considered from the point of station operation. The theory of load curves is set forth, and ways in which they may be applied described in detail.

METALLURGY. By E. Gregory. London and Glasgow, Blackie & Son, 1932. 284 p., illus., 9x6 in., cloth,, 17s 6d.—With an introduction by an experienced teacher. A simple, interesting account of the manufacture, properties, and uses of the common engg. metals. The metallurgy of ferrous materials fills 2/3 and includes chapters on the constitution of metallic systems, metallography, and heat treatment, alloy steels and stainless steels. Remainder treats of common non-ferrous alloys.

RAMBLING THROUGH SCIENCE. By A. L. De Leeuw. N. Y. & Lond., McGraw-Hill, Whittlesey House, 1932. 320 p., 9x6 in., cloth, $2.50.—Readers without special training in modern chemistry, physics, and astronomy will find satisfaction in these informal chapters. Mr. De Leeuw writes conversationally, simply, and clearly on light, sound, relativity, time, space, energy, matter, the elements, and other physical and chemical problems, giving an account which every one can understand of recent scientific discoveries.

REWINDING AND CONNECTING A-C. MOTORS. By D. H. Braymer and A. C. Roe. N. Y. & Lond., McGraw-Hill, 1932. 372 p., illus., 9x6 in., cloth, $3.50.—For technically trained men without shop or factory experience, and students. It aims to provide the fundamental principles of induction-motor windings, and shop information on lap and wave windings as used in current standard motors and in those in service for many years. This information based upon practical experience in rewinding is presented in form suitable for easy use.

ROYAL TECHNICAL COLLEGE JOURNAL, v. 2, Pt. 4, January 1932. Glasgow, Robert Anderson & Sons. p. 571–710, illus., 10x7 in., paper, 10s 6d.—Records research work recently carried out there. Of greatest interest to engineers are the physical properties of steel after plastic and yield-point extension, magnetostriction of cold-drawn wire, aging and tempering duralumin, segregation in steel, production of uniform illumination over large areas, the photoelectric cell, temperature stresses in non-circular drums and circular flat plates, and the performance of wing radiators.

THERMIONIC VACUUM TUBES and Their Applications. By E. V. Appleton. N. Y., E. P. Dutton & Co., 1931. 117 p., 7x4 in., cloth, $1.25.—A compact, accurate account of internal action of modern vacuum tubes and of their behavior when used as amplifiers, rectifiers, or generators of oscillations, written with the needs of students of general physics in mind.

DER INGENIEUR IN DER ELEKTROINDUSTRIE. By R. Salinger. Vienna, H. Martin, 1929. 118 p., 10x6 in., paper, 10 Aust. s.—This book is to assist the young electrical engineer to professional success. It contains much sage advice upon character formation and professional and commercial training, and discusses the qualities and training essential to various branches of the profession.

AMERICAN MACHINISTS' HANDBOOK. By F. H. Colvin and F. A. Stanley. 5 ed. N. Y. & Lond., McGraw-Hill, 1932. 1134 p., charts, tables, 7x4 in., leather, $4.00.—Popular for 24 years in machine shops and drafting rooms as a convienient source of reference on machine shop practise, standards, and materials. The new edition, the first in 6 years, has been revised carefully, obsolete material removed, and new data added.

APPAREILS POUR LE CALCUL MÉCANIQUE DE L'INTÉGRALE DU PRODUIT DE DEUX FONCTIONS. By A. Nessi and L. Nisolle. Paris, Dunod, 1932. 17 p., illus., 11x7 in., 7 frs.—Describes a mechanical integrator invented by the authors to give the integral of the product of 2 functions. The instrument is relatively inexpensive and can be dismantled into parts for other drafting-room purposes. The theory of the integrator is explained and illustrated.

ELECTRIC POWER EQUIPMENT. By J. G. Tarboux. 2 ed. N. Y. & Lond., McGraw-Hill, 1932. 493 p., illus., 9x6 in., cloth, $5.00.—To give the student already familiar with the fundamentals of electrical circuits and machinery a birdseye view of the entire field of electrical power equipment. Starting with a brief survey of power resources, prime movers, and the relation of steam to water power, it discusses loads and load graphs; then takes up generating and switching equipment circuit layouts, transmission lines, distribution systems, substations, and similar topics. The end is a short chapter on the economics of electric service. A new edition enlarged and thoroughly revised.

ELECTRICAL PHENOMENA IN GASES. By K. K. Darrow. Baltimore, Williams & Wilkins Co., 1932. 492 p., illus., 9x6 in., cloth, $8.00.—An important book which will be welcomed by physicists and chemists as a comprehensive up-to-date treatise, with general principles, methods, and experiments set forth clearly and fully. It fills admirably the need of systematic discussion of work in this field, and brings together data heretofore available only in scattered form.

ELEKTRISCHE MASCHINEN, BD. 3. DIE TRANSFORMATOREN. By R. Richter. Berlin, J. Springer, 1932. 321 p., illus., 10x6 in., cloth, 19.50 rm.—A text-book upon the theory and design of transformers, the subject presented concisely yet comprehensively, and emphasizing especially magnetic, electrical, and thermal phenomena. A clear, logical presentation suited to the needs of engineers and students. Includes brief bibliography.

ELEKTRODYNAMIK. (Handbuch der Experimentalphysik, by W. Wien and F. Harms, Bd. 11, Teil 1.) By G. Mie. Leipzig, Akademische Verlagsgesellschaft, 1932. 502 p., illus., 10x7 in., cloth, 45 rm.—A systemtic comprehensive presentation of the methods and apparatus used in the experimental study of electrodynamic phenomena. The magnetic field and the electric current, the dynamic effects of magnetic fields, and electrodynamic fields are discussed.

FIRST PRINCIPLES OF TELEVISION. By A. Dinsdale. N. Y., John Wiley & Sons, 1932. 241 p., illus., 9x6 in., cloth, $3.50.—Not an attempt to describe every system of television that has been tried, but rather to present the principles that have led to present results and to describe the apparatus now in use. After briefly presenting the most outstanding proposals of early workers, attention is confined to the workers who have gone farthest—Jenkins, Baird and the Bell Telephone Laboratories. These systems are described in considerable detail. In conclusion, the present state of television in Germany, England, and America is discussed.

FIXED NITROGEN. (American Chemical Society, Monograph Series No. 59.) Ed. by H. A. Curtis. N. Y., Chem. Cat. Co., 1932. 517 p., illus., 9x6 in., cloth, $12.00.—The product of a dozen authors, all past or present members of the Fixed Nitrogen Research Laboratory staff at Washington. The main theme is exposition of scientific facts and theories of nitrogen fixation, and of the essentials of commercial processes to obtain and elaborate nitrogen compounds. An extensive bibliography is given.

GENERAL TEXT ON AERONAUTICS. By H. F. Lusk. N. Y., Ronald Press Co., 1932. 420 p., illus., 8x5 in., cloth, $3.25.—Presenting fundamentals of aeronautics in form suitable for use in technical institutes, junior colleges, and aviation ground schools where students are in training for positions in the aviation industry. The principles of flight, construction of airplanes and engines, instruments used, piloting, meteorology, etc., are discussed in elementary fashion. A good introductory course covering information which the Department of Commerce expects airplane pilots to learn in ground schools.

HISTORY OF EXPERIMENTAL PHYSICS. By C. T. Chase. N. Y., D. Van Nostrand Co., 1932. 195 p., illus., 9x6 in., cloth, $2.25.—The book is devoted to the development of physics as an experimental science from the days of Galileo. Attention is directed to history making, researches, and reasons given as to why these are of interest. Present developments are clearly described non-mathematically. The book supplies an interesting account of the gradual advance in this field.

INTERNATIONAL TRADERS' HANDBOOK, incorporating foreign and domestic weights, measures, and moneys. Phila., Commercial Museum, 1932. 175 p., illus., 9x6 in., paper, $1.50.—Useful as desk book for manufacturers engaged in trade with foreign countries, presenting in brief convenient tables, the essential facts concerning trade centers and ports, language, transportation facilities, regulations governing freight and parcel post shipments, weights and measures, and conversion of moneys.

ORTSKURVEN DER STARKSTROMTECHNIK. By G. Hauffe. Berlin, J. Springer, 1932. 174 p., 10x6 in., cloth, 15.50 rm.—Here the method of complex quantities is systematically applied to the theory of locus curves, the book opening with a brief description of the method, followed by a concise summary of the necessary basic laws of electrical engineering. The application of the theory is illustrated by problems connected with oscillating circuits, air-core transformers, three-phase induction motors, and a-c. commutator motors. It closes with a systematic presentation of the general laws of the theory.

OUTLOOK FOR TELEVISION. By O. E. Dunlap. N. Y. & Lond., Harper & Brothers, 1932. 297 p., illus., 10x6 in., cloth, $4.00.—A book "to reveal the romance of television and its commercial possibilities; to record historically the evolution of a new era in radio science; and to explain its magic." The development of all important advances is traced chronologically and the various electrical systems, devices, and ideas used in the search for television are noted. Intended for the general reader, with the subject treated in a popular, non-technical style.

POTENTIALFELDER DER ELEKTROTECHNIK. By F. Ollendorff. Berlin, J. Springer, 1932. 395 p., 10x6 in., cloth, 32 rm.—A systematic course on the subject, intended to facilitate the solution of practical problems in electrical engineering. The opening chapters briefly summarize physical principles, after which the construction of potential fields is discussed at length. The latter half of the book considers boundary problems. Represents the course given at the Berlin Technical High School.

QUANTITATIVE ANALYSIS. By E. G. Mahin. 4 ed. N. Y. & Lond., McGraw-Hill, 1932. 623 p., illus., 8x6 in., cloth, $4.00.—A popular textbook to provide a theoretical and practical discussion to meet the needs of college students. Emphasis is placed upon the scientific principles that form the basis of practical methods of analysis. The book discusses the general processes, the special measurements used in laboratories, and the analysis of the common industrial products and raw materials. This edition has been revised throughout.

### Engineering Societies Library

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MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

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A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

# Industrial Notes

**The Okonite Company Promotes Officers.**—According to a recent announcement, H. Durant Cheever, former president of the Okonite Company, has been made chairman of the Board, while the position of president is now occupied by Frank Cazenove Jones. Mr. Jones was formerly vice-president and general manager of the company, while in the new position he holds the title of president and general manager. Both men have long been members of the Okonite organization, Mr. Cheever's connection dating back for 44 years. Mr. Jones, who is also chairman of the Power Cable Group of NEMA, joined the Okonite Company after the war. His father, F. C. Jones, was manager of the Okonite factories.

**Hubbard & Co. to Manufacture Ohio Brass Line Hardware.**—The Ohio Brass Company, Mansfield, Ohio, announces that it has disposed of its line of wood cross-arm hardware, wood guy-strain insulators and steel insulator pins to Hubbard and Company, Pittsburgh, Pa. The latter company is licensed to manufacture and sell pole line hardware developed by Ohio Brass and protected by its patents. This is a manufacturing and sales arrangement only, and there is no financial interest of either company in the other. These materials, in the future, will be manufactured only by Hubbard and Company, although both companies will cooperate in the sale of the devices. Future development work on this class of materials also will be carried forward by both companies. Due to the specialized manufacture and engineering of similar materials by Hubbard, both companies expect that users will benefit by this cooperative arrangement.

**Large Clock Contract to Warren Telechron Company.**—Contracts for 2,650 synchronous electric clocks for three new government buildings were awarded the latter part of July to the Warren Telechron Company, Ashland, Mass. Approximately 1,100 clocks will be installed in the Department of Justice building, 1,100 in the Interstate Commerce Commission and Labor Department building, and 450 in the Post Office Department building. The recent installation of 875 Telechron clocks in the Internal Revenue building is one of the largest clock systems in the world.

**Special Electrical Machine for College Laboratories.**—It is sometimes difficult for students of electrical engineering to understand the relationship between direct and alternating-current rotating machines. If these relationships may be studied in a single machine, the connections being changed for the different conditions, it is easier for the student to visualize the actual operation. The Electric Specialty Co., of Stamford, Conn., therefore, has developed a machine which enables the student of electrical engineering to study the operation of the direct-current motor with and without commutating poles, the direct-current generator also with and without commutating poles, rotary converters operating from direct current to alternating current, or from alternating current to direct current, a-c. generators, and a-c. synchronous motors. The single machine may be used to illustrate the operation of all these types. Such a machine may also be equipped with exploring brushes for measuring the voltage between adjacent commutator bars in any position while in operation. A single conductor is also installed through one of the armature slots with each end terminating on a slip-ring fitted with brushes. This development has been completed for machines normally rated from about 3500 to 7500 volt-amperes as rotary converters. Machines of this size are about as small as could be used in order to obtain satisfactory results on all the different types of machines, and also are not so large as to involve too much expense in operation.

**New Time Switch.**—R. W. Cramer & Co., Inc., 67 Irving Pl., New York, announces a new type of Sauter synchronous motor time switch, gear operated. The new switch contains a self-starting, 200 r.p.m. sub-synchronous motor constructed to assure accurate time keeping on systems where controlled frequency is used. It can be had with either astronomic dial to automatically operate the switch in step with local sunset and sunrise throughout the year, or a plain dial to control either one or two complete operations in twenty-four hours. This switch is recommended by the manufacturer for use on alternating current circuits with regulated frequency.

# Trade Literature

**Overhead A-C. Network System.**—Bulletin C 1944, 8 pp. Describes the new application of economical secondary low voltage networks to low density load areas fed by overhead lines. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

**Induction Motors.**—Bulletin 112, 4 pp. Describes Reliance fully enclosed, fan cooled induction motors, type AA, form F. Reliance Electric & Engg. Co., Ivanhoe Rd., Cleveland, O.

**Stainless Steel Motor.**—Bulletin, 4 pp. Describes "Linc-Weld" type "E" induction motor, totally enclosed, fan cooled, for use in dust or fume-laden atmospheres. The Lincoln Electric Company, Cleveland, O.

**Temperature Measurements in Electrical Apparatus.**—Bulletin 871, 28 pp. Describes the method and instruments employed in measuring temperatures in generators, transformers, and cable systems. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

**Squirrel Cage Motors.**—Bulletin 174, Part 5, 6 pp. Describes Wagner multi-speed squirrel-cage motors. Installation photographs are included as well as outlines of the problems involved in connection with each application. The description covers constant-torque, constant-horse-power and variable-torque motors, further classified as two-speed, three-speed, and four-speed motors. Wagner Electric Corp., 6400 Plymouth Ave., St. Louis, Mo.

**Electrical Tape.**—Pocket Bulletin, 16 pp. Describes a combination rubber tape and friction tape. The tape is made of fabric, completely imbedded in a unique rubber compound, and with a degree of adhesion and insulating value claimed to be far higher than ordinary tapes of this character. B. F. Goodrich Company, Akron, O.

**Copper Wire and Coils.**—Data sheets bound in loose leaf cover and convenient for ready reference. These bulletins are said to be the most complete and authoritative published up to this time on the subject. Inca Mfg. Div., Phelps-Dodge Copper Products Corp., Ft. Wayne, Ind.

**Cedar Poles.**—Pocket Bulletin, 100 pp., "Handbook of Cedar Pole Specifications." All available data on cedar poles is brought up-to-date in this new publication, featuring the new American Standards Association specifications for both western red and northern white cedar poles, and the new Western Red Cedar Association treating specifications. To facilitate handy reference to the old pole specifications, these are also included. MacGillis & Gibbs Co., 324 East Wisconsin Ave., Milwaukee, Wis.

**Oil Filled Cables.**—Bulletin. The Okonite-Callender Cable Company, Inc., a subsidiary of the Okonite Company outlines its new activity in manufacturing oil-filled, paper insulated cables. The company's factory at Paterson, N. J., is devoted to the production of impregnated paper-insulated cables of all types. In addition to its regular business of manufacturing the "solid" type of paper-insulated cables, its laboratory and plant have also been fully equipped for making cables of the oil-filled type. The pamphlet points out research and operating developments in extra-high voltage power transmission which have led to the application of oil-filled cables for certain conditions of use. In many underground plants, the growing needs for high operating voltages or for large conductors, without increasing the overall sizes of cables, have become important problems. As some power companies already have costly conduit systems which could not be enlarged or replaced without excessive cost, the application of the oil-filled cables may often present a feasible means of taking care of such conditions. The relative operating characteristics of the solid and oil-filled types are discussed in the bulletin and the subject matter should be interesting where such problems are existing, or where reviews of plant conditions indicate the need of revamping in the future.

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## This Month—

### Front Cover

Rock Island hydroelectric plant of the Puget Sound Power & Light Company, Wash., the first electric power development on the famous Columbia River, and the first large low head installation on the Pacific Coast. This plant is situated east of the Cascade Mountains about 13 miles downstream from Wenatchee; its initial capacity is 60,000 kw. See p. 654–9 of this issue. Stone & Webster Photo

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CORRECTION. Through an error in the author's original manuscript, eq. 11 on p. 486 of the July issue of ELECTRICAL ENGINEERING is stated incorrectly; the correct form is $S = \frac{1}{2}\pi^2 E_0 \cdot \frac{c}{L} \cdot \frac{A}{L}$

MEMBERS of the Institute continue to express themselves upon various subjects through the medium of letters to the Editor. A selection from those received recently may be found in this issue. *p. 667–670*

OFFICERS AND COMMITTEES chosen to serve the Institute for the year 1932–33 were announced recently. *p. 678–681*

DESIGNED to provide primarily for the comfort and convenience of its occupants, the 33-story office building of the Philadelphia (Pa.) Saving Fund Society is said to contain the most modern electrical and mechanical equipment. The total connected electric light and power load is nearly 5,000 kw. *p. 621–624*

PRESIDENT HOOVER recently appointed 6 prominent engineers to serve as the engineering advisory board to the Reconstruction Finance Corporation. *p. 665–666*

EXPERIMENTS on the electric arc using pure iron electrodes in an inert atmosphere reveal information that may require a modification in the basic conception of the electric arc discharge. *p. 624–627*

A REPORT on proposed American standard electrical definitions is now available in pamphlet form. The report represents 3 years of effort on the part of a sectional committee of the A.I.E.E. standards committee, and contains 208 pages. *p. 670*

IF EXPERIMENTS on a 1,000-hp. locomotive with commutatorless motors confirm the results of laboratory tests, electric railway practise may be revolutionized. Mercury arc rectifiers replace not only the motor commutators but much expensive control apparatus as well. *p. 650–654*

BUT few operating difficulties have been experienced in 3 years of operation on the electrified portion of the Cascade division of the Great Northern Railway, which includes the famous 7.79-mile Cascade tunnel. Operating statistics show great savings in both time and expense in favor of electrical operation versus steam. *p. 627–633*

COMMITTEES are hard at work to assure those who will attend the Baltimore meeting, October 10–13, 1932, a profitable and enjoyable visit. Inspection trips have been arranged to some of the city's many attractions and to nearby points. The program includes also several sports events and special features for the ladies. *p. 663–665.* Technical papers to be presented deal chiefly with communication and power cables, and a major hydroelectric development. *p. 659–662*

A GREAT DEAL of engineering time and effort is being devoted to reducing lightning disturbances on electric power systems. Results of some recent studies on the protection of distribution systems are covered in a group of 3 articles in this issue. Tests show that interconnecting the primary lightning arrester ground with the grounded secondary neutral provides greater protection than is obtained with present conventional arrester connections. *p. 633–647*

*A Report on*

# Telemetering, Supervisory Control, and Associated Communication Circuits

*Prepared by a joint subcommittee of the A.I.E.E.**

THIS REPORT summarizes information as to telemetering and supervisory control systems in use today or commercially available in the United States, and includes a detailed discussion of the communication circuits suitable for such purposes. The form of the report is designed to make it convenient for a prospective or existing user of telemetering or supervisory control equipment to obtain information concerning the specific equipment in which he may be interested.

The tabulations in the telemetering and supervisory control sections enable the prospective user having in mind a certain requirement, for example the telemetering of a-c watts, to determine immediately the systems available for the purpose. The characteristics of each of the systems suitable for the telemetering of a-c watts may then be examined in detail with the aid of the table and consideration narrowed to a few systems concerning which additional information may be desired from the manufacturer in order to determine upon the one best suited to the conditions involved. The types of communication circuits suitable for operation with each telemetering or supervisory control system are indicated in the tables.

The information in the report has been arranged in 3 main sections:

I. Telemetering—including a tabulation of the characteristics of each system.

II. Supervisory Control—including a tabulation similar to that for telemetering.

III. Communication circuits—information concerning their use for Telemetering and Supervisory Control Systems.

Much of the information in this report has been contributed by the manufacturers. Information as to communication circuits has been obtained from the communication companies and other available sources.

No attempt has been made to include data covering the field operation and maintenance of the various telemetering and supervisory control systems.

**On this and the following 7 pages is given essentially the full text of an hitherto unpublished report concerning the present status of development of proven devices as used in telemetering and supervisory control services. The text of the report as published herewith was prepared by D. W. Taylor, chairman of the A.I.E.E. automatic stations committee, and E. I. Green, member of the joint subcommittee, to cover the subjects embraced by the original report, but of necessity eliminating the extensive and detailed tabulations of that report. However, in parts I and II of the accompanying article is given a comprehensive digest of the corresponding parts of the original report including an insight into the content and construction of the tabulations which form the major portion of those parts of the original report. Part III of the original report, presenting for the first time in published form a comprehensive discussion of the communication circuits and facilities involved in telemetering and supervisory control, is given here in its entirety. That the report in question may be kept up to date and improved in value, the committees involved earnestly solicit an interchange of information with all parties operating telemetering and supervisory control equipment. —Editors.**

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Essentially full text (excepting extensive tabulations) of a report jointly prepared by the committees listed below and presented at the A.I.E.E. annual summer convention at Cleveland, Ohio, June 20–24, 1932. *A few lithographed copies of the full report are available at Institute headquarters for distribution to members vitally interested.*

*Joint subcommittee—C. F. Craig, *chairman;* A. E. Anderson, P. A. Borden, E. D. Doyle, E. I. Green, R. J. Wensley, F. Zogbaum.

Committee on automatic stations—D. W. Taylor, *chairman;* F. F. Ambuhl, A. E. Anderson, L. D. Bale, C. F. Craig, John Fies, A. M. Garrett, Joseph Hellenthal, C. A. Mayo, I. E. Moultrop, M. E. Reagan, O. J. Rotty, Garland Stamper, L. J. Turley, F. Zogbaum.

Committee on instruments and measurements—E. J. Rutan, *chairman;* H. S. Baker, R. D. Bean, O. J. Bliss, P. A. Borden, H B. Brooks, A. L. Cook, E. D. Doyle, W. W. Eberhardt, Marion Eppley, W. N. Goodwin, Jr., I. F. Kinnard, O. A. Knopp, A. E. Knowlton, H. C. Koenig, W. B. Kouwenhoven, F. A. Laws, E. S. Lee, J. B. Lunsford, Paul MacGahan, R. T. Pierce, W. J. Shackelton, H. L. Thomson, H. M. Turner.

# I—Telemetering

HEREIN *telemetering* is considered to be the indicating, recording, or integrating of a quantity at a remote point by electrical translating means. Electrical or mechanical quantities normally are involved, although there are other miscellaneous applications for telemetering.

## TYPES AND CHARACTERISTICS OF SYSTEMS

The numerous systems and combinations of equipment used for telemetering may be classified broadly on the basis of the translating means employed. Such classification has been recommended to the Institute for adoption, and includes: (1) Current, (2) Frequency, (3) Impulse, (4) Position, and (5) Voltage.

This report endeavors to present a uniform analysis of existing systems. The characteristics have been detailed under items which past engineering experience indicates to be essential to bring out the design, installation, and performance features. In order to cover the entire field, it has seemed desirable to present the information in tabular form. The user ordinarily will be concerned only with a limited number of systems, and the arrangement of the information is such that he easily can fix upon the system or systems which appear best to meet his requirements.

The different telemetering systems which have been included in the table are as follows:

| | Name of System | Manufacturer |
|---|---|---|
| 1. | Midworth distant repeater | J. G. Biddle Co. |
| 2. | Long distance transmitting and recording system | The Bristol Co. |
| 3. | Remote type transmitting and recording system | Brown Instrument Co. |
| 4. | TM flow meter | Builders Iron Foundry |
| 5. | MacCreedy fluid level indicator | J. H. Bunnell & Co. |
| 6. | Long distance recorder | Esterline-Angus Co. |
| 7. | "Elinco" remote indicating system | Electric Indicator Corp. |
| 8. | Magnetic impulse telemeter | General Electric Co. |
| 9. | Rectified current telemeter | General Electric Co. |
| 10. | Torque balance telemeter | General Electric Co. |
| 11. | Selsyn equipment | General Electric Co. |
| 12. | Demand metering system | General Electric Co. |
| 13. | Distant dial system | General Electric Co. |
| 14. | Long distance outfit | W. & L. E. Gurley |
| 15. | Telemetric gage | James S. Kennedy |
| 16. | Micromax thermal converter telemeter | Leeds & Northrup Co. |
| 17. | Micromax potentiometer transmitter telemeter | Leeds & Northrup Co. |
| 18. | Micromax voltage multiplier telemeter | Leeds & Northrup Co. |
| 19. | Micromax current balance telemeter | Leeds & Northrup Co. |
| 20. | Micromax wheatstone bridge telemeter | Leeds & Northrup Co. |
| 21. | Stevens Type P recorders and indicators | Leupold, Volpel & Co. |
| 22. | Stevens Type G recorders and indicators | Leupold, Volpel & Co. |
| 23. | Telemco gage | Pittsburgh Equitable Meter Co. |
| 24. | Conductance meter | Republic Flow Meters Co. |
| 25. | Fluid meter register | Simplex Valve & Meter Co. |
| 26. | Tanner type telemeter | Wallace & Tiernan Products Co. |
| 27. | Wallace type telemeter | Wallace & Tiernan Products Co. |
| 28. | Electronic current balance system | Westinghouse Elec. & Mfg. Co. |
| 29. | Current balance system | Westinghouse Elec. & Mfg. Co. |
| 30. | Low rate impulse system | Westinghouse Elec. & Mfg. Co. |
| 31. | High rate impulse system | Westinghouse Elec. & Mfg. Co. |
| 32. | Rectox system | Westinghouse Elec. & Mfg. Co. |
| 33. | Position indicator | Westinghouse Elec. & Mfg. Co. |

The characteristics of the above systems are listed in the tables under the following classification.

**General**
1. Manufacturer
2. Trade name
3. Method of operation (translating means)

**Character of Indications Provided**
4. Quantities measured
   Electrical Quantities
   a. Amperes, a-c
   b. Amperes, d-c
   c. Ampere-hours, d-c
   d. Frequency
   e. Integrated demand
   f. Power factor
   g. Reactive voltamperes
   h. Reactive voltampere hours
   i. Totalized watts, a-c
   j. Totalized watthours, a-c
   k. Volts, a-c
   l. Volts, d-c
   m. Voltampere hours
   n. Voltage phase angle difference
   o. Watts, a-c
   p. Watthours, a-c
   Other Quantities
   a. Levels
   b. Positions
   c. Pressures
   d. Quantities of flow
   e. Rates of flow
   f. Temperatures
5. Continuous or step-by-step indication

**Performance**
6. Speed of response—seconds
   a. Transmitter—zero to full scale reading
   b. Lag from transmitter to receiver
   c. Total
7. Estimate of maximum probable error under normal operating conditions (per cent of full scale)
8. Power requirements
   a. Transmitter
   b. Receiver
9. Will correct indication be given after:
   a. Interruption in power supply
   b. Temporary disconnection of line circuit

**Characteristics Affecting Line Transmission**
10. Frequency—cycles per second
11. Maximum number of impulses per minute
12. Is neutral or polar relay employed
13. Maximum allowable loop resistance—ohms
14. Minimum allowable insulation resistance—megohms
15. Number of conductors
16. Possibility of using ground as conductor
17. Possibility of using conductors exposed to high potentials
18. Possibility of using superposed circuits as conductors:
    a. Simplexed
    b. Composited
    c. Carrier

**Interference and Protection Features**
19. Normal line current
20. Maximum line current on short circuit
21. Maximum open circuit voltage
    a. Between wires
    b. To ground
22. Is additional equipment required to limit noise on adjacent telephone circuits
23. Description of system

### Power Supply at High Voltage Stations

The use of station batteries for the supplying of power telemetering transmitters located in high voltage stations is generally inadvisable. Station batteries usually are connected to an extensive network of local control wires having a high electrical capacitance to ground, and subject to contact or leakage to ground. For reliability a separate battery or other insulated source should be used. This battery should be charged from a separate, ungrounded generator or rectifier; and if alternating current be used it should be supplied from a separate ungrounded transformer fed from the low voltage station bus which should be grounded.

## II—Supervisory Control

SUPERVISORY control provides, by electrical means and over a relatively small number of conductors, for the selective control and supervision of several remotely located units of equipment or apparatus. It is the purpose of this report to present to the prospective user information that will enable him to select the equipment which will provide the desired operating features and at the same time function satisfactorily in connection with available communication circuits.

### Applications

At present, supervisory control systems have their greatest field of application in power systems, where they are used for the automatic operation of apparatus in generating, switching, transformer, or conversion stations. These systems are employed also in water, gas, oil, and other industries for the operation of pumping stations, and the control of levels and pressures of gases, liquids, etc. Supervisory control is applicable in general to the remote control and supervision of any device that may be operated electrically. A partial list of such devices is included in Section 26 (Automatic Stations) of A.I.E.E. Standards.

In addition to the control features provided, indications of the position of different devices such as switch positions, governor settings, gate and valve openings, and of such conditions as bearing and winding temperatures, pressures, levels, synchronization, may be secured. Arrangements for the telemetering of various quantities may be incorporated in control systems.

### Performance Features

Features generally desirable in supervisory control equipment may be summarized as:

1. The highest degree of reliability and speed obtainable in the correct selection of units, with due regard for economy.
2. Safeguarding of a selected unit against incorrect operation and the correct operation of a unit as quickly after its selection as is consistent with safety.
3. A visual and/or audible indication at the control point of changes occurring in the position of any of the supervised units.
4. Automatic notification at the control point of the occurrence of major troubles such as open, shorted, or grounded conductors, and the loss of operating potential in a distant station, that may cause the supervisory control system to become inoperative.
5. Safeguarding against false operation in the event of failure of any portion of the supervisory control equipment to function.

### Capacity—Power Supply

Some of the supervisory control equipments have structural features which impose more or less definite physical limitations as to the number of units that may be supervised from one system. Other equipments may be used to supervise any number of units that may be installed. Some stations may be of such size and importance as to justify more than one supervisory control installation.

The comments under telemetering relating to power supply practises in high voltage stations apply with equal force to supervisory control. In addition, special care should be exercised where supervisory wiring is connected to units located in a high voltage structure.

In the full report the supervisory control systems have been tabulated in a manner somewhat similar to the arrangement for telemetering systems. The following systems have been included:

| | Name of System | Manufacturer |
|---|---|---|
| 1. | Selectrol system | General Control Corp. |
| 2. | Synchronous selector system | General Electric Co. |
| 3. | 2-Wire synchronous selector system | General Electric Co. |
| 4. | 2-Wire code selector system | General Electric Co. |
| 5. | Code synchronous selector system | General Electric Co. |
| 6. | Audible selector system | General Electric Co. |
| 7. | Audible indicating system | General Electric Co. |
| 8. | Synchronous visual system | Westinghouse Elec. & Mfg. Co. |
| 9. | Visicode radial system | Westinghouse Elec. & Mfg. Co. |
| 10. | Visicode series system | Westinghouse Elec. & Mfg. Co. |
| 11. | Visicode parallel system | Westinghouse Elec. & Mfg. Co. |
| 12. | Audicode system | Westinghouse Elec. & Mfg. Co. |
| 13. | Televox system | Westinghouse Elec. & Mfg. Co. |
| 14. | Polaricode system | Westinghouse Elec. & Mfg. Co. |
| 15. | Polaricode radial parallel system | Westinghouse Elec. & Mfg. Co. |

Characteristics of the supervisory control devices covered by the report are tabulated therein, the tables embracing the following items:

General
1. Manufacturer
2. Trade name
3. Method of selection
4. Method of checking selection
5. Method of operation
6. Method of indication

Characteristics of System
7. Number of units
    a. Maximum recommended for one system
    b. Normal physical limitation
8. Maximum number of stations recommended for parallel operation over one group of communication circuits. (See item 20)
9. Power requirements
    a. Dispatching station
    b. Distant station

10. Time required to select and check
    a. 10th unit
    b. 20th unit
11. Having selected unit, can it be operated repeatedly without again performing selecting operation
12. Is automatic indication given to dispatcher
    a. Line open
    b. Line short
    c. Line ground
13. Can telephone conversation be carried over same communication circuit, intermittent or continuous
14. Is selective telemetering possible over same communication circuits
15. Is remote manual synchronization possible over same communication circuits

**Characteristics Affecting Line Transmission**

16. Maximum number impulses per sec
17. Is neutral or polar relay used
18. Maximum allowable loop resistance
19. Minimum allowable insulation resistance
20. Number of conductors
21. Possibility of using ground as a conductor
22. Possibility of using Superposed circuit as conductor
    a. Simplex
    b. Composite
    c. Carrier
23. Can system operate through insulating transformers

**Interference and Protective Features**

24. Normal line current
25. Maximum line current on short circuit
26. Maximum line volts open circuit
    a. Between wires
    b. To ground
27. How is system protected from electrostatic and electromagnetic induction when exposed to high potential circuits
28. Is additional equipment required to limit noise in adjacent telephone circuits
29. Description of system

# III—Communication Circuits

TELEMETERING and supervisory control systems may be operated over different types of communication circuits. It is not practicable to set down rules which will definitely determine the type of circuit to be used in a given case. The choice will depend upon the characteristics of the equipment, the available types of circuits, the operating distance, cost factors, and other circumstances. The transmission and engineering considerations involved in the selection are discussed in the following paragraphs.

## LINE SIGNALS—TRANSLATING MEANS

The systems described involve the transmission of the following types of signals:

1. D-c signals representing voltage or current, which change in accordance with the quantity to be measured.
2. D-c impulse signals, ranging in frequency from one impulse per minute to 15 impulses per sec.
3. Power frequencies, usually 60 cycles.
4. Frequencies in the voice range and above.

Only a limited use of frequencies in the voice range or above is being made in telemetering and supervisory control systems. The following discussion therefore is concerned primarily with circuits for the transmission of low frequency and d-c signals. The problems involved in the transmission of such signals over line circuits are similar in many respects to those encountered in d-c telegraph transmission and the same engineering considerations frequently apply.

Telemetering systems ordinarily transmit in one direction only, whereas supervisory control systems commonly require successive transmissions in opposite directions.

## CIRCUIT CHARACTERISTICS

Circuits for use with telemetering or supervisory control systems may be leased or may be owned by the user of the equipment. Both cable and open wire facilities are employed for these services, cable being in more general use. The line characteristics that may affect the operating range of low frequency systems are principally the linear resistance, to a lesser extent the leakage conductance (or insulation resistance), and occasionally the linear capacity or inductance.

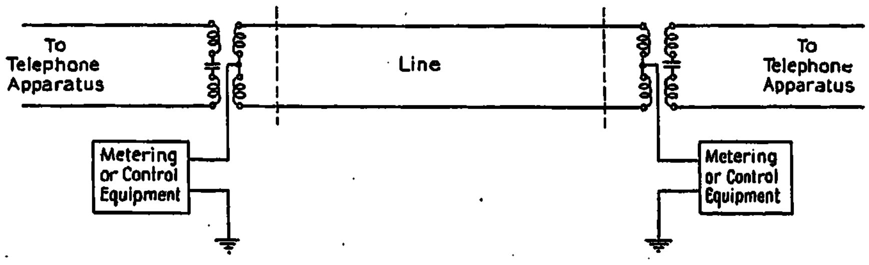

**Fig. 1. Grounded low frequency circuit derived from simplexed telephone circuit**

The gage of cable most commonly used is No. 19 A.W.G., although relatively short lengths of 22, 24, or 26 gage cable frequently are employed in cities.

The gages of open wire commonly employed by the communication companies are 165-mil (No. 8 B.W.G.), 128-mil (No. 10 N.B.S.G.), and 104-mil (No. 12 N.B.S.G.), which coincide closely with those frequently used by the electric utilities and other industries; namely, 162-mil (No. 6 A.W.G.), 128.5-mil (No. 8 A.W.G.), and 101.9-mil (No. 10 A.W.G.).

The insulation resistance of cable circuits ordinarily is so high that it is not an important factor in the operation of telemetering and supervisory control systems. The insulation values obtained on open wire circuits in general are very much lower than those for cable circuits. Consequently, leakage frequently is the limiting factor in determining the range over which telemetering and supervisory control systems may be operated on open wire facilities. The leakage conductance varies over wide limits, depending chiefly upon weather conditions and the type and maintenance of the line, and to a smaller extent upon the insulators employed. Since the leakage in dry weather is negligible compared to that in wet weather, it is common practise to engineer systems on the basis of wet weather leakage values. For the purpose of determining the approximate range and accuracy of telemetering and control systems, it appears convenient to employ a single leakage value which may be considered to be representative for any open wire circuit. On this basis, the

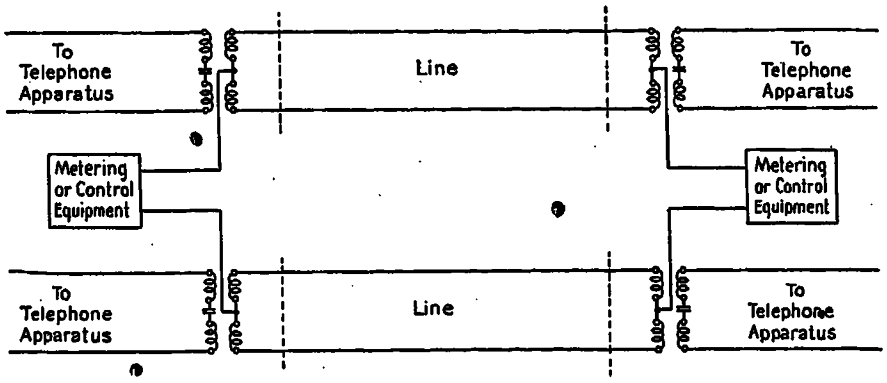

Fig. 2. Metallic low frequency circuit derived from simplexed telephone circuits

value of wet weather leakage conductance between one wire and ground may be taken as 5 micromhos per mile (0.20 megohm-mile). It is thought that on the average this value will not be exceeded on more than about one day out of a hundred and then only for a part of the day, although individual sections of the country may vary materially in this respect. The wet weather leakage conductance between wires probably will not be more than 2.5 micromhos per mile.

For determining the effect of uniformly distributed leakage conductance upon the accuracy of a d-c telemetering system, the percentage error usually may be taken as equal to 50 times the ratio of loop resistance in ohms to total insulation resistance in ohms.

The telemetering and control systems described require from 2 to 6 conductors, but since 2-conductor systems predominate, this discussion is directed primarily toward such circuits. The principles involved may be extended readily to systems requiring 3 or more conductors.

Circuits may be divided into 2 classes: metallic circuits in which a metallic conducting path is employed throughout, and grounded circuits in which the ground is used as one side. For many applications metallic circuits constitute a more desirable transmission medium than grounded circuits. However, the latter are satisfactory in many cases and ordinarily can be obtained at a low cost.

The simplest forms of circuits which may be used are: a circuit consisting of two conductors, and a circuit consisting of a single conductor and ground. More complicated arrangements are encountered when it is desired to superpose the telemetering or supervisory control channel on a circuit which also is used for telephone purposes. Such superposition is accomplished by simplexing or compositing.

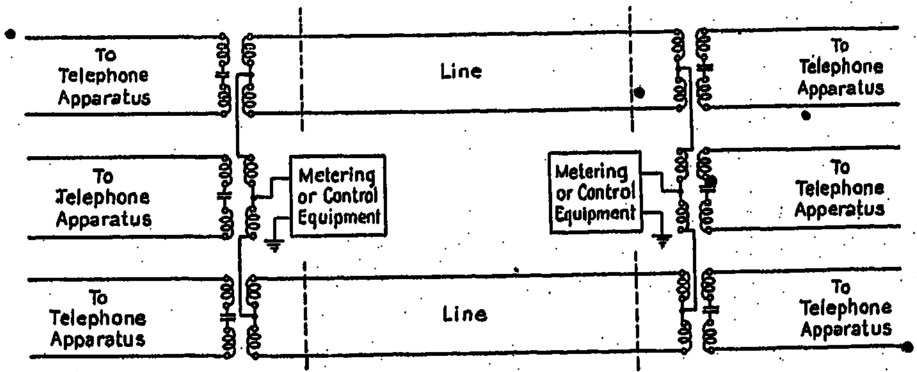

Fig. 3. Grounded low frequency circuit derived from simplexed phantom circuit

## SIMPLEX ARRANGEMENTS

The simplex method, illustrated in Fig. 1 as applied to the derivation of a grounded circuit, is based upon the principle of balance. If the telephone circuit is perfectly balanced there will be no net emf or current produced in either the telephone circuit or the derived simplex circuit by signals being transmitted over the other. The use of two telephone circuits to derive a single metallic low frequency circuit is shown in Fig. 2.

If a telephone pair is simplexed it cannot be used as a part of a phantom circuit. However, a phantom may be created from 2 pairs of conductors in the usual manner, and the phantom may be simplexed so as to give one grounded low frequency circuit over the four wires in parallel.

Simplexing connects the line conductors in parallel for the low frequency circuit. Circuit resistance thus is reduced correspondingly, but its linear leakage and capacity are increased.

## COMPOSITE ARRANGEMENTS

In superposing a low frequency circuit on a telephone circuit by compositing, use is made of frequency discrimination. The use of terminal composite equipment to derive 2 grounded low frequency circuits from a single telephone circuit is illustrated in Fig. 3 whereas Fig. 4 shows a single metallic low frequency circuit derived in a similar manner. The composite terminal equipment may be considered as consisting of a high-pass filter which freely transmits the telephone currents while attenuating the low frequency currents, and a low-pass filter which passes the low frequencies and attenuates the telephone frequencies. The low frequency band provided by the composite set extends roughly to 75 cycles, while the high frequency band extends upward from about 135 cycles.

## CONSIDERATIONS AFFECTING SUPERPOSITION

Transmission considerations involved in the use of simplexed or composited circuits for telemetering and supervisory control purposes are similar in general to those which apply in d-c telegraph transmission. For the longer open wire circuits it frequently will be desirable to composite rather than to simplex, because of the smaller leakage values obtained with composited circuits. Also, for the same reason

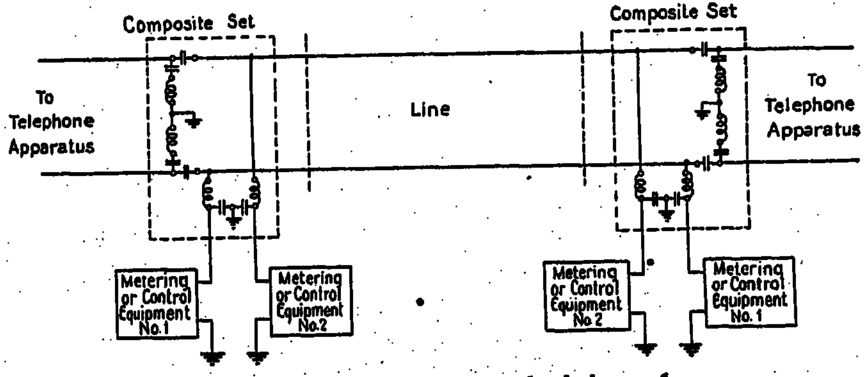
Composite Set
Composite Set
To Telephone Apparatus
Line
To Telephone Apparatus
Metering or Control Equipment No.1
Metering or Control Equipment No.2
Metering or Control Equipment No.2
Metering or Control Equipment No.1

Fig. 4. Derivation of 2 grounded low frequency circuits from composited telephone circuit

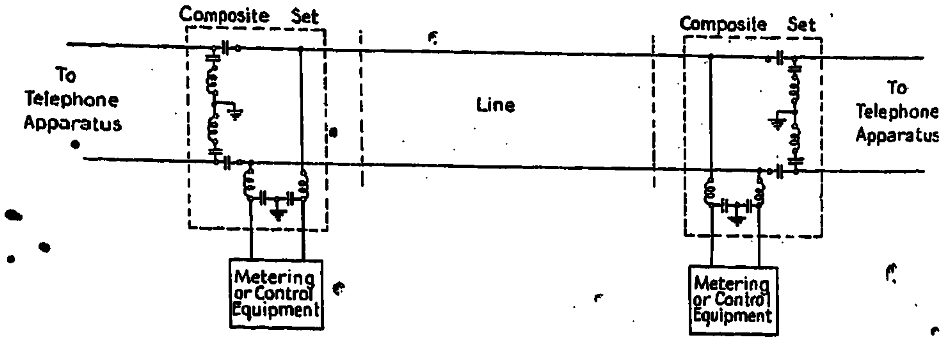

Fig. 5. Derivation of metallic low frequency circuit from composited telephone circuit

a composited open wire physical circuit normally is to be preferred to a composited open wire phantom.

Superposition frequently is accomplished not at the terminals of the telemetering or supervisory control system, but at some intermediate point, a simple metallic or grounded circuit being used from that point to the system terminal. The low frequency circuit may, of course, be superposed on several different telephone circuits in different parts of its length.

The circuit lengths for which superposition may be considered, ordinarily will be in excess of 1 or 2 miles.

### COMMON CIRCUITS

In some instances where a single metallic telephone circuit is available a suitable circuit arrangement will permit the use of this circuit also as a metallic low frequency circuit. In such cases the principal problem frequently is that of transmitting the telephone ringing current and the telemetering or control current without mutual interference. An arrangement employed for the derivation of a metallic circuit for a d-c telemetering system from a metallic telephone circuit is shown in Fig. 5. In this case the low frequency ringing (16 or 20 cycles) is applied to ground.

When several metallic circuits are desired between the same two terminals it is possible under certain conditions to use a single metallic conducting path as a common return, thus effecting an economy in the number of separate metallic paths required. This plan usually is feasible only for short distances where the circuit resistance is small in comparison with that of the terminals. It has been used successfully for systems employing d-c impulse signals.

### MAINTENANCE AND INTERFERENCE PROTECTION

Since telemetering and supervisory control services generally are of vital importance in the fields in which they are applied, the highest practicable degree of continuity and reliability of operation is essential in most cases. Some of the procedures which have been found helpful include:

1. Special markings at the terminals, frames, protectors, test boards, etc., where the circuits appear. These serve to guard against possible interference or interruption to service.
2. Frequent routine tests and inspections of the facilities.
3. Arrangements for prompt location and clearing of troubles.
4. Arrangements for prompt restoration of service in the event of failure.

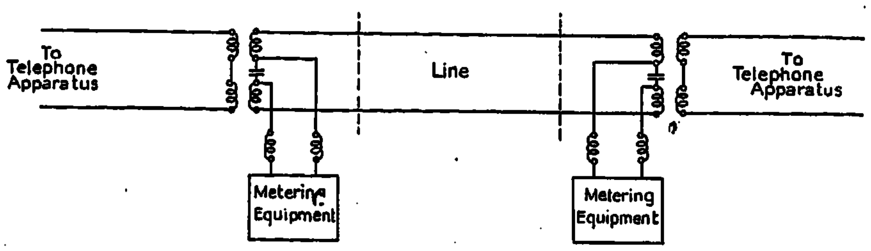

Fig. 6. Derivation of metallic d-c circuit from single telephone circuit

In operating telemetering and supervisory control systems in connection with different types of communication circuits, the application of certain requirements and limitations as to protection and interference conditions has been found desirable. These have been determined with a view to:

1. The provision of a satisfactory grade of telemetering and supervisory control service.
2. The avoidance of possible hazard to communication plant and personnel.
3. Avoidance of possible interference with communication services.

The requirements and limitations usually desirable for low frequency telemetering and supervisory control systems may be briefly summarized as:

a. The potential of a d-c supply under any conditions should not exceed 135 volts positive or negative between any conductor and ground. A potential of 270 volts may be employed between the 2 wires of a pair provided the midpoint of the applied voltage is grounded.

b. The potential of an a-c supply should not exceed 120 volts rms value between conductors or between any conductor and ground.

c. The maximum line current under any conditions should not exceed 0.35 amp. (In some types of loaded telephone conductors the maximum current is limited to 0.10 amp.)

d. Where there is a possibility of experiencing excessive ground potentials there should be no metallic connection between the line facilities and the high voltage station ground.

e. The apparatus should be provided with insulation adequate for the conditions under which it is to be used.

f. Not more than 50,000 noise units should be impressed on a paired metallic circuit. The noise impressed on any two wires not in the same pair, or between any wire and ground, should not exceed 10,000 noise units.

The communication companies generally are equipped to make noise measurements in cooperation with the user of the telemetering or supervisory control equipment. The above provisions agree, in general, with those observed in the operation of commercial telephone plant. When the user of telemetering or supervisory control equipment provides his own circuits it is sometimes possible to exceed these limitations without undesirable effects. Many of the systems now furnished by the various manufacturing companies are designed and constructed so as to conform to the provisions listed above.

### GROUND POTENTIALS AND THEIR EFFECTS

An item of interest in metering and control services is the possible occurrence of differences between the ground potentials at the two ends of the circuit that may be of sufficient magnitude to cause appreciable interference in grounded circuits. Metallic circuits, on the contrary, are very rarely affected by ground potentials.

Differences in ground potentials ordinarily are small (not more than 10 volts). However, in a few locations in the United States the geological formation is such that varying differences of substantial magnitude in ground potential occur more or less continuously. Difficulties incident to this cause may be overcome by an arrangement known as a ground potential compensator, which will neutralize ground potential differences up to about +100 volts.

The effect of ground potentials on telemetering and control circuits depends, of course, upon the type of system. As a rule, the accuracy of telemetering systems which use a slowly varying direct voltage or current is affected by ground potentials. Consequently, metallic circuits generally are more desirable for such services. Systems employing d-c impulses, however, are much less susceptible in this respect, and usually are not affected by small differences in ground potentials. Therefore, grounded circuits may be used successfully in many applications of these latter types of systems.

Where several telemetering or supervisory control systems employing relay operation are to be used between the same terminals, an arrangement may be provided whereby a grounded channel is used for each system and a single auxiliary conductor is used to compensate for the effect of ground potentials in all systems.

## Power Interference

In certain cases the transfer of energy from power circuits may introduce substantial alternating voltages and currents into circuits used for telemetering and supervisory control systems. If circuits closely parallel power line rights-of-way, special drainage and protection arrangements ordinarily will be required. In the more usual cases where signal circuits are less severely exposed to the power circuits, appreciable induction may be experienced during normal operation of the power system, but disturbances caused by abnormal occurrences on the power circuits, such as short circuits or grounds, will be of greater importance.

As in the case of differences in ground potential, metallic circuits are much less susceptible to power interference than are grounded circuits. Also, cable circuits are much less affected than open wire circuits. The amount of actual interference that such power induction may produce in telemetering and supervisory control systems depends, of course, upon the type of system employed and upon the magnitude of the effects present.

If a high voltage station ground or a nearby ground is used for grounded telemetering or supervisory control circuits these circuits are extremely susceptible to interference at times of abnormal conditions in the power system. This difficulty may be obviated by using an operating ground at an intermediate point (such as a telephone central office) some distance away from the high voltage station and employing a metallic circuit between that point and the high voltage station. This makes possible the use of a grounded circuit in sections not affected by disturbing potentials. The metallic circuit extending to the high voltage station must, of course, be insulated against the maximum potentials to which it may be subjected.

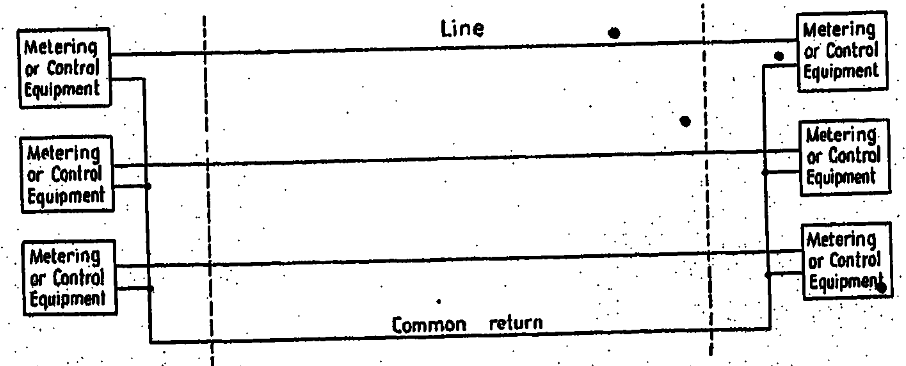
Metering or Control Equipment
Line
Metering or Control Equipment
Metering or Control Equipment
Metering or Control Equipment
Metering or Control Equipment
Metering or Control Equipment
Common return

**Fig. 7. Common return circuits**

## Operating Distances

The distance over which satisfactory operation may be secured with different types of telemetering and supervisory control systems depends both upon the design of the system and the character of the associated communication circuits. Ordinarily the manufacturer will indicate the approximate length of different types of circuits over which his equipment will yield a satisfactory performance. The scope of this report does not permit a statement of the maximum distances which may be spanned with each equipment as applied to each type of circuit. A few general observations, however, may be helpful.

For cable circuits, especially of the metallic type, the resistance usually is the principal factor in determining the operating range. With open wire circuits, the leakage frequently will be the controlling factor.

For systems having the higher speeds of transmitting impulses and for 60-cycle systems, especially when operated on simplexed or composited facilities, the effects of capacity and inductance in the communication circuit and in the compositing equipment will limit the length to much shorter values than those determined by resistance only.

In general, the positions of type telemetering systems are best suited to comparatively short distances, perhaps up to 5 miles.

The voltage and current types of telemetering systems cover, in general, a range of operating distances up to about 50 miles, with greater ranges

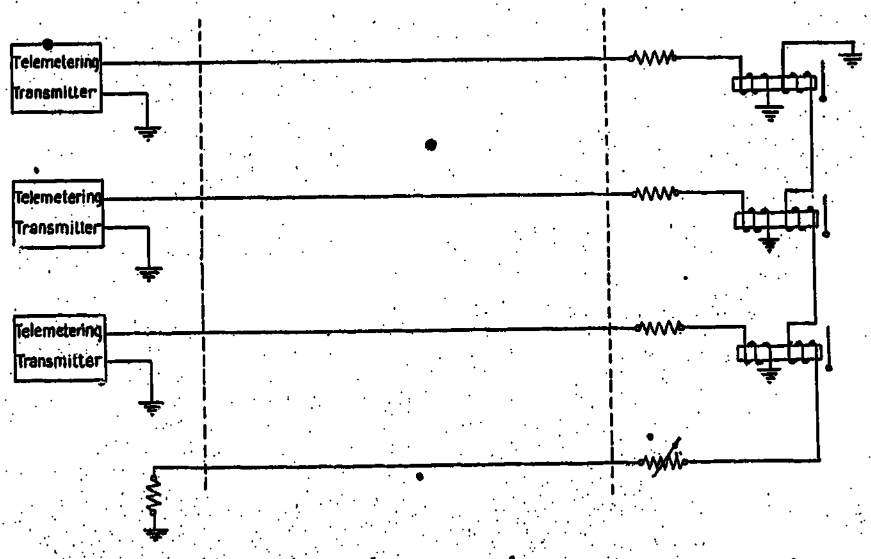

**Fig. 8. Use of auxiliary conductor to compensate for ground potentials**

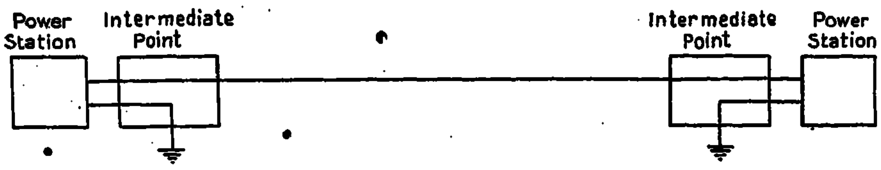

Fig. 9. Use of ground at intermediate points

feasible if simplexed cable circuits are used. The accuracy of these systems is affected appreciably by the leakage on open wire circuits. Metallic circuits are preferable for these systems; in fact, are essential for certain types.

Systems employing d-c impulses generally will span a maximum distance of from 50 to 250 miles or more. These systems are well adapted to the use of grounded channels, and their accuracy is not impaired by leakage conditions. For systems employing relay operation, greater distances usually may be spanned and superior operating results obtained by the use of polar operation or the equivalent instead of open-and-close operation.

Repeaters, for the most part, are unnecessary for the distances normally to be covered. In cases where it is desired to span unusually long distances, certain of the systems employing d-c impulse signals may be repeatered with ordinary telegraph repeaters. Also, repeaters employing equipment similar to the terminal equipment for some of the systems can be furnished by the manufacturers.

### Circuits for Voice Frequency

The employment of signals in and above the voice frequency range is practicable for telemetering and supervisory control systems, although in most cases d-c or low frequency signals have been used. Some of the more important reasons for their usage are:

1. The employment of the voice frequency range for these purposes sacrifices its utility for telephone purposes.
2. The avoidance of interference with adjacent services is readily obtained by the utilization of the low frequencies.

The protection provisions desirable for telemetering and supervisory control systems employing frequencies in or above the voice range are somewhat the same as for low frequency systems. Where there is a possibility of interference with other services, the amount of energy usually is determined on the basis that the signaling energy should be comparable in its interfering effect with the normal voice currents.

## IV—Conclusion

Considering the rapid advances in the art, a report of this nature, summarizing the present available information concerning telemetering and supervisory control systems, undoubtedly will be out of date in a relatively short time. It is hoped that frequent contributions will be received from users of telemetering and supervisory control equipment reporting their experiences with this apparatus so that this report may be supplemented from time to time as may seem desirable. The committee will be glad to assemble and correlate any comments of this nature that may be offered.

# New Radio Tube Has Attractive Characteristics

Putting into apparently successful practical application the results of several independent research efforts, a new radio tube of interesting characteristics recently has been brought into the market. Known as the "Wunderlich Tube" this device is specially designed to serve as a high quality detector which combines full-wave rectification with a stage of audio amplification and provides also, all within one tube structure, the necessary voltage for the automatic control of sensitivity.

This new tube may be described as a coplanar grid tube in which grid rectification is obtained by employing 2 grids as the 2 anodes in a full-wave rectifier circuit, while these grids act in parallel to amplify the rectifier audio-frequency voltage, developed across the grid leak and grid condenser. The coplanar grid arrangement increases the power handling capacity of the grid-leak detector by giving greater output and also permitting the development of a voltage sufficient for automatic volume control purposes. The tube, of course, is distinctly different, both in construction and operation, from any of the other tubes now commercially available. It may be thought of as being an ordinary 3-electrode tube to which there has been added a second grid wound between the meshes at the usual grid, and developed in this instance to give a combined power detector and automatic volume control tube all in one. The detecting action is of the power-grid rectification type and, because of the coplanar arrangement, is able to deliver approximately twice as much undistorted output as can the ordinary triode type of grid rectifier. The volume control function is said to be performed without interfering in any way with the tube's primary function as a detector. Experiments seem to show that various control groupings can be arranged depending upon the characteristics of the particular circuit in which the tube is to be used.

The tube derives its name from Norman E. Wunderlich (A'27) of Chicago who, in cooperation with the Arcturus Radio Tube Company of Newark, N. J., has sponsored this first commercial coplanar grid type of vacuum tube to be placed upon the

American market. Some details pertaining to earlier efforts to develop a commercial type of coplanar grid tube are described in a paper, "A Study of the Output Power Obtained From Vacuum Tubes of Different Types," prepared by H. A. Pidgeon and J. O. McNally (A'26) which may be found on p. 266 of the February 1930 issue of the *Proceedings* of the Institute of Radio Engineers. Experimental and theoretical data supporting the contention that satisfactory power grid leak detection could be obtained were given in a paper, "Some Properties of Grid Leak Power Detection," prepared by F. E. Terman (A'23) associate professor of electrical engineering at Stanford University (California) and N. R. Morgan, then a graduate student at Stanford. This paper may be found in the December 1930 *Proceedings* of the I. R. E. The Wunderlich tube is the first commercial development to make use of these works and its evolution shows a serious attempt to develop a new tube capable of performing the functions for which present day receivers require 2 tubes.

# "Nothing More Modern"

**Electrical features of the Philadelphia Saving Fund Building include unusually high artificial illumination and complete air cooling and conditioning equipment, serving the entire building. The installation involves some unique designs and new applications of engineering materials. Owners, architects, and engineers have cooperated to secure a highly modern and practical structure.**

By
**C. D. FAWCETT**
MEMBER A.I.E.E.
Associated with Howe and Lescaze, architects, and with H. Berkeley Hackett, consulting engineer, Philadelphia, Pa.

THE OLDEST savings bank in America, the Philadelphia (Pa.) Saving Fund Society, now is completing construction of a new 33-story bank and office building of the most modern functional design in America. With electrical and mechanical equipment selected to provide extensively for the comfort and convenience of its occupants, the building provides: elevator service 20 per cent faster than found in typical similar structures; for natural lighting efficiency, an outside wall area 65 per cent glass; for artificial lighting efficiency, an indirect system providing on all normal working planes an evenly diffused non-glare illumination of 19 ft-c; for exterior decorative effects, floodlighting near the ground, panel lighting near the roof, and a 27 × 120-ft neon sign on the roof; for the health and comfort of those in the building a complete recirculating air cooling and conditioning system, with full temperature and humidity control. Communication, alarm, and signal systems installed provide extensive facilities for telephone, radio, television, telegraph, stock ticker, telautograph, and synchronous time services. It is contemplated that the building will stand as a creditable monument to its owners, architects, and engineers, as an exemplification of their design slogan, "Nothing more modern."

Electric service to the building is supplied over 2 13.2-kv 3-phase 60-cycle circuits from independent sources. Two isolated sections of 13.2-kv bus and duplicate low voltage buses for power and light distribution are designed to operate normally with half of the entire building load on each of the 2 incoming high voltage feeders, with arrangements to interconnect automatically the 2 sections of the high voltage bus in the event of the failure of either feeder. The control facilities provide for manual rather than automatic restoration of normal service conditions after automatic transfer. Automatic interlocks on both the high voltage and low voltage circuit breakers prevent inadvertent paralleling of the 2 main service feeders. For extreme emergency conditions, full manual control may be established through a master release which makes the normal interlocking features inoperative. Since local system volt-

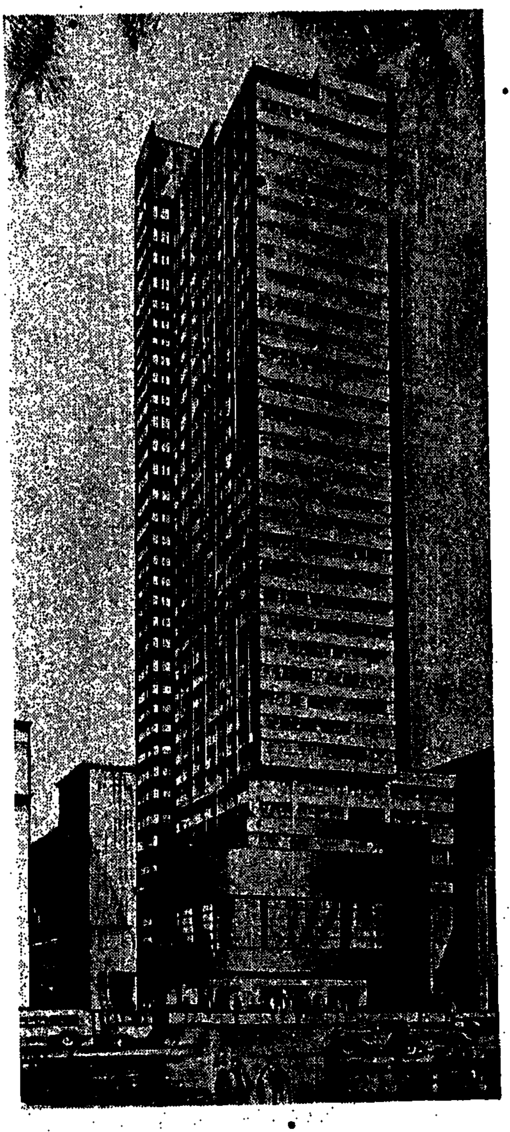

Fig. 1. Architect's drawing of "America's most modern" commercial structure, the 33-story bank and office building of the Philadelphia Saving Fund Society

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Written especially for ELECTRICAL ENGINEERING by Mr. Fawcett, who in addition to his consulting activity is professor of electrical engineering at the Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa. *Not published in pamphlet form.*

age regulation is very good, no regulators were installed, 2 2.5 per cent taps above and below the normal 13.2-kv connection on each of the main transformers being supplied for possible future changes in nominal voltage values.

In the sub-basement substation, a 3-section semicircular duplex control board centralizes the control and metering for all circuits. The outside sections of the board carry triplex ammeters, respectively, for the power and the lighting feeders; the center section carries a dummy bus with a complete complement of pilot lights and control switches for operating all high voltage switches and the bus-tie and inter-bus emergency transfer switches, all necessary ammeters, wattmeters, power factor meters, totalizing graphic wattmeter, and graphic voltmeters for the power and light buses. The rear doors of the panel boards carry associated relays and test blocks, and also give access to the wiring. For all control wiring, multiple-conductor colored control cable is used, housed in accessible wire-ways placed at the top of the switchboard sections to protect against possible damage from flood waters.

Power for all service motors and elevators throughout the building is distributed over 3-wire 3-phase 60-cycle circuits at a nominal rating of 440 volts, whereas lighting equipment is fed from a nominal 199–115-volt 3-phase 4-wire 60-cycle grounded-neutral system. An auto-transformer is provided for the emergency transfer of energy between the light and power buses in the event of failure of one of the main transformers. Color identified wires and cables are used throughout the building for all low voltage feeders, subfeeders, and branch circuits for both light and power. Two special elevator feeders run the full height of the building, each with taps at the 20th floor for the low rise elevators, and at the 33rd floor for the high rise elevators. Each elevator feeder has copper capacity sufficient to serve all elevators, and switching facilities to provide for the transfer of any elevator to either feeder and hence to either of the building services. An excellent opportunity thus is provided for balancing power loads, for balancing power factor on the service feeders, and for inspection and maintenance requirements. In addition to the 2 elevator circuits there are 9 power feeders and 9 lighting feeders, and provisions for one spare feeder for replacing any defective lighting feeder. All circuits for the lighting system, including the transformers, have been designed and installed for a capacity approximately 50 per cent greater than the present connected load.

An interesting departure from common practise is presented in the design used in both low voltage bus feeders and in the corresponding distribution risers

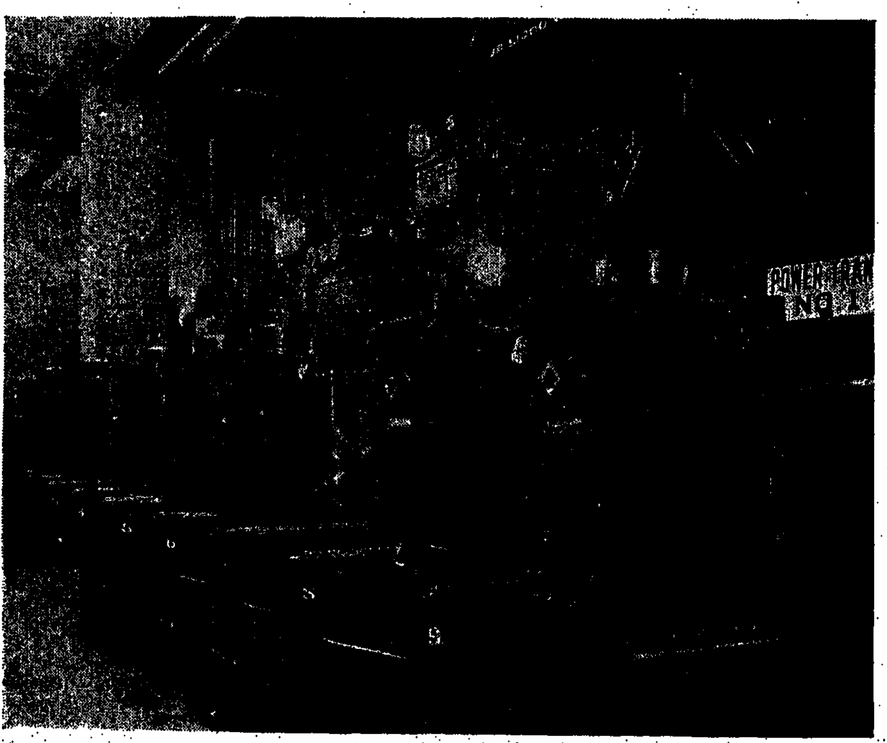

Fig. 2. Seven metalclad oil circuit breakers serve the 13.2-kv bus, 2 for incoming service lines, 2 for power supply, 2 for lighting supply, and one service bus tie

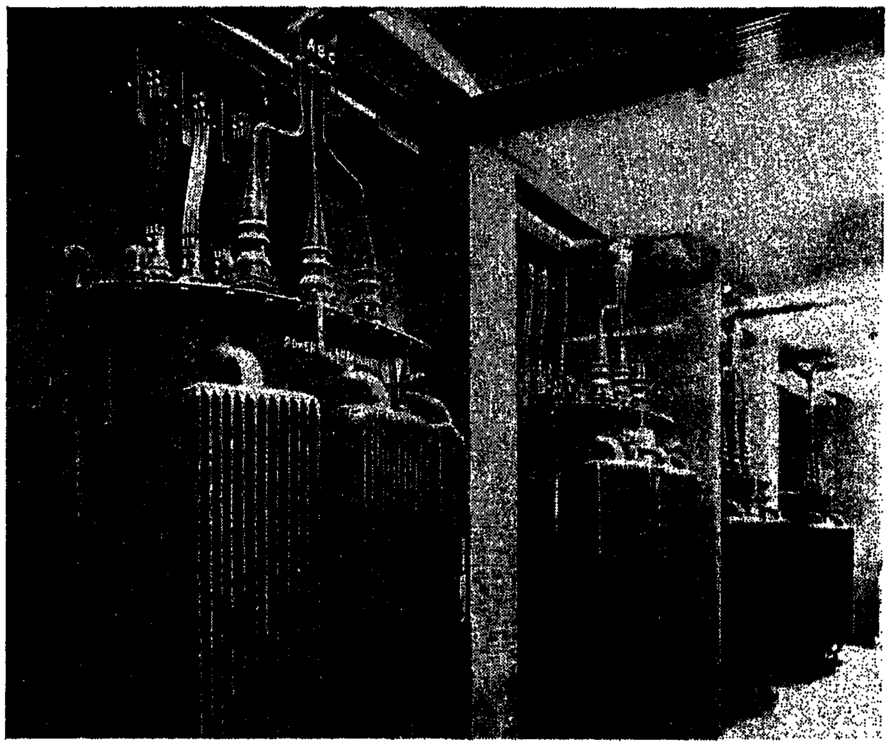

Fig. 3. Oil-insulated self-cooled transformer equipment includes 2 1,200-kva 3-phase units for power supply, 2 750-kva 3-phase units for lighting supply, and one 750-kva 3-phase auto-transformer unit (not shown) for emergency interconnection between the 440-volt power buses and the 115–199-volt 4-wire lighting buses

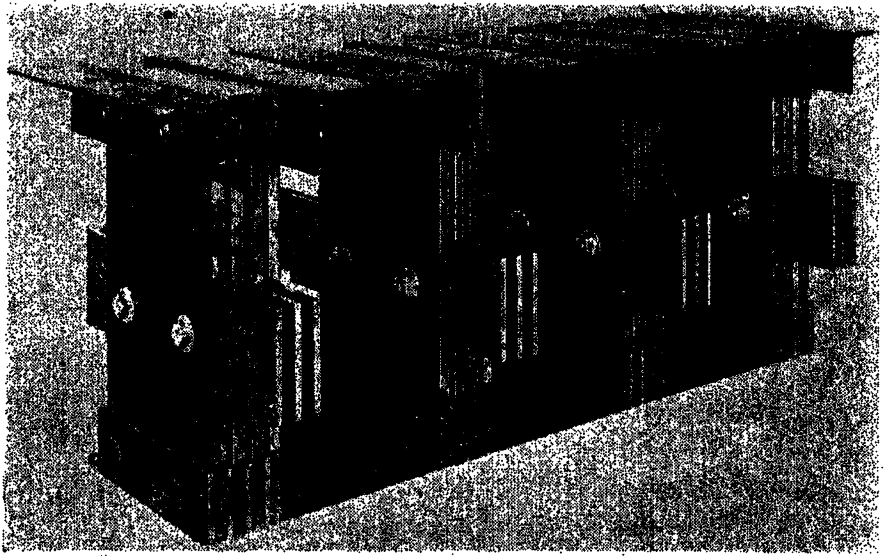

Fig. 4. The use of sheet insulation in the bus assemblies speeded construction, simplified expansion problems, proved no more costly than the more usual types of construction and will expedite inspection and repair

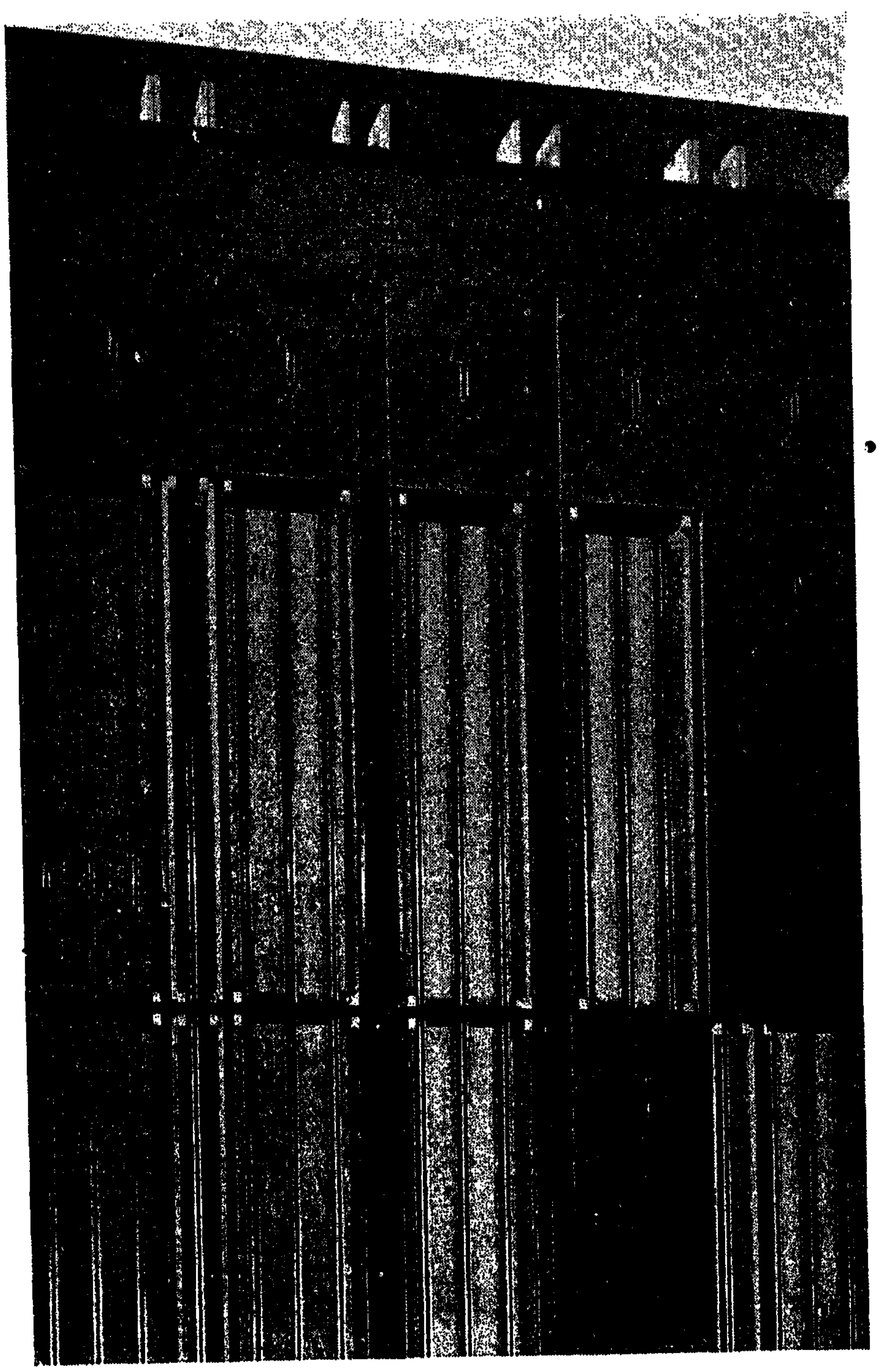

Fig. 5. Steel feeder compartments for the wire shaft which extends the entire height of the building were factory-made in sections for each floor span. Feeder conductors consist of 2 1/4 × 2-in. flat copper strips per phase, designed for a current density of 800 amp per sq in., and supported and spaced by sections of sheet insulation. For tap-offs, special connection boxes fitted with suitable outlets are substituted for the plain covers shown

through the building. In both instances, flat copper strap of convenient proportion was used, spaced, insulated, and supported by flat sheets of composition insulating material. An example of this construction as used in the main low voltage buses may be seen in Fig. 4, where it may be noted also that the supporting sheet insulation is mounted by means of bolts sliding in slotted angle iron pieces which in turn are bolted to the concrete floor slabs. This latter construction is used for long runs and, with flexible cable connections at the ends of the runs, takes care of all temperature expansion and contraction in the bus copper. Electrical and mechanical tests have indicated high factors of safety under both dry and wet conditions.

A related type of construction is used for the main vertical distribution circuits as indicated in Fig. 5. The steel raceways carrying these circuits line the wire shaft on 2 sides from the sub-basement to the 32nd floor. In these steel feeder compartments the flat copper conductors are guided and spaced by sheet insulation spacers located every 4 ft, and the weight is supported by vertical sheets of insulating material. Each phase of bus-bar feeder is supported at the middle of a 120-ft vertical section by one of these sheet-insulation supports, and the expansion is upward and downward from that fixed point. Woven copper straps, surrounded with composition phase-spacers take care of the expansion between these sections.

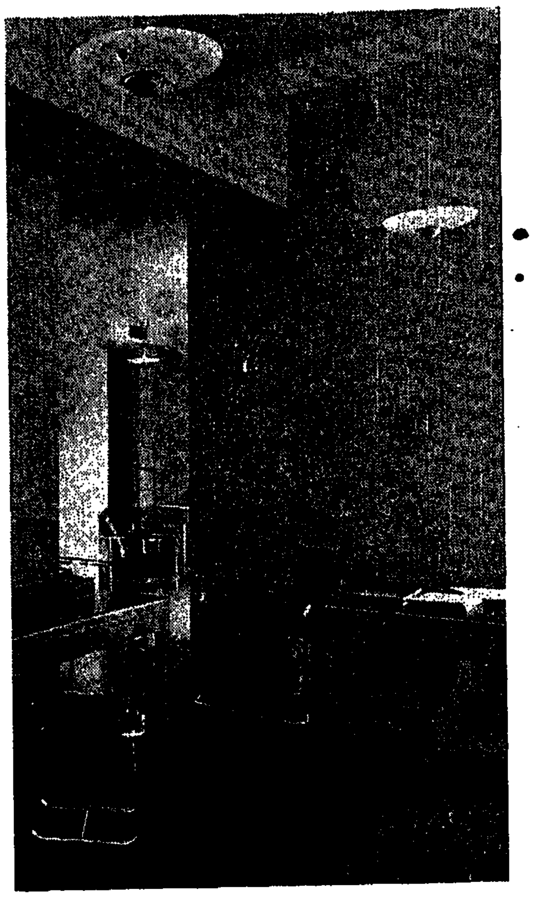

Fig. 6. Lighting fixtures are severely simple in contour and finish, and economical in first cost and maintenance. They use 200-watt silvered-bowl processed lamps hung 40 in. below the ceiling on 8 1/2 to 9 1/2-ft centers

Over the entire length of the wire shaft compartment covers are removable and tap-off feeders are housed in enclosing boxes which fit into the spaces otherwise normally occupied by the compartment covers, thus providing convenient connection at any desired point. Between the adjacent steel feeder compartments there exist, as a "by-product" of the design, wire raceways approximately 3 × 6 in. in cross-section in which low-capacity rubber-insulated cables and control wiring for various building services are installed. The whole design is safe, fireproof, compact, easily accessible for inspection and repair, economical in first cost, and readily capable of expansion in copper capacity and extra tap-offs without loss of existing materials.

The principal features of illumination in the building, as already mentioned, include relatively high intensity of interior illumination and the neon sign of spectacular proportions on the roof. The exceptionally fine lighting effect with the 19 ft-c of evenly diffused light is secured by the simple unit shown in Fig. 6. To eliminate glare and specular reflection, the light gray walls and white ceilings are painted with a non-gloss finish.

The neon sign on the roof of the building about 500 ft. above the sidewalk is one of the largest in the United States. Each letter is 27 ft high, 9 in. in depth, 15 ft wide, and has a 22-in. stroke. The letters are supported in free space 30 in. in front of a solid metal plate background which spans 120 ft in a horizontal direction. The letters are of simple block form, painted white and with porcelain enamel face; the background is a deep cobalt-blue. Approximately 1,000 ft of 12-mm 30-ma neon-filled tubes are used to provide illumination at the center of the letter strokes. Visibility and tube light output tests now being conducted may alter somewhat the ultimate tube specifications. It is expected that the sign may be read from a distance of 3½ miles at night and 3 miles in the daytime.

In summarizing some of the outstanding electrical features of this building it is of some interest to note that some 64 per cent of the building motor load is required for the air conditioning and circulating equipment, in addition to the motors installed as spare units. Other pertinent data are given in the following tabulation:

| | | |
|---|---|---|
| Total connected motor load (exclusive of spare units) | | 3.620 hp |
| Elevator load | 1,046 hp | |
| Air-conditioning load | 2,310 hp | |
| Domestic water system | 121 hp | |
| Heating system (for condensate, etc.) | 41 hp | |
| Miscellaneous applications | 102 hp | |
| Total connected motor load (approx.) | | 3,100 kw |
| Total connected lighting load | | 1,676 kw |
| Grand total connected light and power load | | 4,776 kw |
| Total over-all volume of building | | 7,977,000 cu ft |
| Total over-all floor space | | 562,680 sq ft |
| Space rented by P.S.F.S. (owners) | 62,900 sq ft | |
| Office space, rentable area | 328,510 sq ft | |
| Store space, rentable area | 35,140 sq ft | |
| Non-rentable area | 136,130 sq ft | |

# Researches in Arc Welding

**Research of extreme importance in the field of electric welding is reviewed briefly in this progress report. Laboratory tests have demonstrated the impossibility to strike an arc with 120 volts between pure iron electrodes in an atmosphere of pure argon, an observation that may require the modification of basic conceptions of the nature of the electric arc discharge.**

By

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IN INDUSTRIAL electric arc welding it is often difficult to say, once good or bad results have been obtained, just why they are good or why bad, and if bad just which of the dozen or more variables in the process was responsible. Obviously many inferior welds are being made in this maze without leading to any definite conclusion. Some of the variables are:

1. Kind of steel welded—that is, the chemical composition, heat treatment, amount of included matter, and surface condition of the parts welded
2. Kind of electrode wire used
3. Preparation of parts prior to welding
4. Kind of welding machine used
5. The human element in the operator's work
6. Subsequent heat treatment of weld
7. A host of others.

It has been proposed that this admittedly complex but industrially important problem be studied by statistical methods in which each variable in every welding operation, together with the degree of success of the operation, be recorded on a series of cards which could then be sorted and the rôle of each variable so evaluated. The other obvious method of attack is the method of abstracting the basic simplified system from the usual complex system; such as using *pure* iron for electrodes and for the parts to be joined, and performing the welding in an inert and therefore non-participating atmosphere. This latter is the method adopted by the present authors and supported by the A.I.E.E. through a grant from Engineering Foundation in 1930, and supported also by Lehigh University.

The successful completion of this project should establish a base line both for the behavior of arcs and for the qualities of welds of pure iron in a non-participating atmosphere. Once the characteristics of an iron arc are known, and once the physical, chemical, mechanical, and metallurgical properties of pure iron welds are established, all more complicated alloys such as commercial steels then could be referred to that base line as a standard, and a judgment could be made of the effects of each alloy element, whether desirable or undesirable. Thus, questions such as: "What should be the phosphorus or sulfur content of steel for welding? Is nitrogen in steel detrimental for welding? What about the best composition for welding wire? What is the action of air on the arc and on the weld metal?" today unanswered, could gradually be answered by reference to the pure iron base line, and the wastefulness and uncertainty of guessing eliminated.

## Purity of Materials

Pure iron in the form of wire $^1/_8$ in. in diameter and plates $^1/_8$ in. thick was contributed for these studies. A special method was followed in the preparation of these experimental samples from ferrous chlorid ($FeCl_2$) of reagent grade. This material analyzed as follows:

| | |
|---|---|
| $SO_3$ | 0.0005 per cent |
| As | 0.0000 per cent |
| Cu | 0.0000 per cent |
| Zn | 0.008 per cent |

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Specially prepared for ELECTRICAL ENGINEERING; includes the essential substance of a progress report presented informally before the welding session of the A.I.E.E. 1932 winter convention, the substance of important discussion arising from that presentation, and the results of subsequent research. *Not published in pamphlet form.*

It then was partially converted to oxid by heating in a porcelain dish in an oven. Decomposition was completed by adding chemically pure concentrated nitric acid ($HNO_3$) and reheating in an oven. The ferric oxid ($Fe_2Cl_6$) thus produced was reduced in hydrogen in a porcelain tube to give metal powder. After that, the powder was sintered and drawn into a wire, and finally heated in a tungsten grid vacuum furnace.

Argon gas with total impurities amounting to only 0.0003 (30 parts per million), the purest gas obtainable in quantity, was used for the experiments. The arc chamber, *AC* in Fig. 1, was made of pyrex glass, as also was the auxiliary purification chamber *PC* and all connections. The auxiliary chamber contained a second arc, supplied by a separate 500-volt circuit. The arc in this chamber had misch metal (reactive metals such as cerium or lanthanum) as one electrode. With such an electrode, the metal which vaporizes from it reacts with any reactive gases in the argon and the compounds so formed deposit on the walls of the chamber. This has been reported upon in some detail by Dr. Saul Dushman in the Franklin Institute *Journal* for June 1931.

## ARCS IN ARGON

In tests made with argon gas as received, in moist air and in dry air, all metal parts except the iron wires, but including the copper grips *CC* and the glass chambers, were baked out previously in a hydrogen furnace to expel gases. The chambers then were exhausted, filled with argon, again exhausted and filled, and the arc struck between electrodes *EE* by turning the ground glass lug *L*. Runs made without operating the misch metal arc further to purify the argon gas as purchased, gave a normal arc discharge at *EE* with an impressed potential of 120 volts. The results so obtained, while valuable, were not especially noteworthy. The length of the arc was measured by projection onto a screen; the current and voltage by Weston standard laboratory meters. The results are shown in the characteristic curves in Figs. 2 and 3. Currents higher than 2.5 amp could not be used without consumption of the electrode. For comparison with the argon, similar runs were made in slowly circulating dry air and in circulating moist air. These characteristic curves for dry air and for moist air arcs of pure iron are included in Figs. 2 and 3.

As Fig. 2 shows, the arcs in air, both dry and moist, require a substantially higher voltage than the arc in argon. Also, the arc in air cannot be extended to such lengths as the arc in argon, which latter goes to 9 mm without extinction. In most cases the voltage of arcs of a given length in dry air are lower than in moist air, as reported also by Shrum and Wiest at the 1931 winter convention of the A.I.E.E. (A.I.E.E. TRANS., v. 50, June 1931, p. 650–5). Both 1-amp arcs show irregularly high voltages indicating probably that the arc was in transition between the first and second arc stages. Further information concerning this may be found in papers by S. Maisel (*Phys. Zeit.*, v. 550, 1904); C. P. Steinmetz (*Trans.* Elec. Cong., St. Louis, v. 2, p. 704, 1904); Cady and Arnold (*Am. Jl. of Science*, v. 24, p. 383, Nov. 1907). At 4 mm the dry air arc curves of Fig. 3 show breaks at all currents. No explanation for this irregularity is offered at present. In other respects the curves in

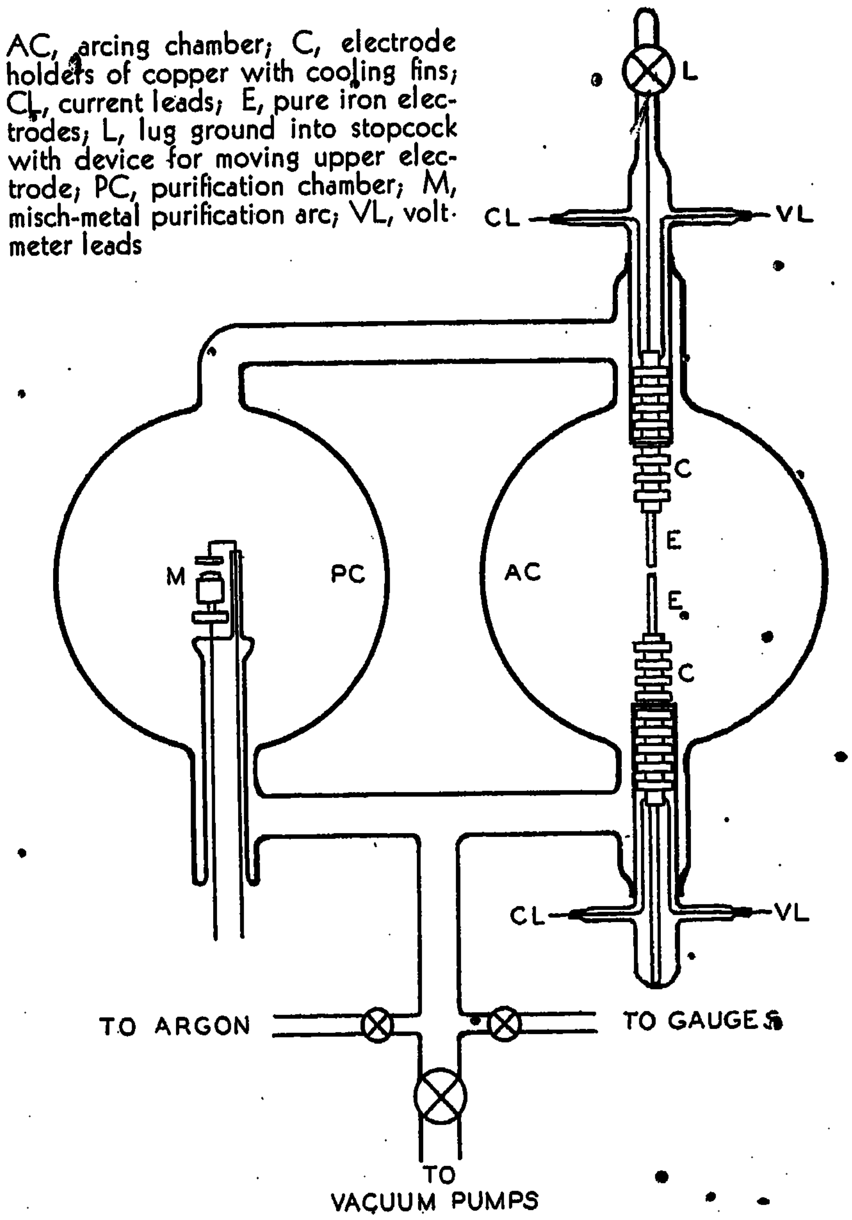
AC, arcing chamber; C, electrode holders of copper with cooling fins; CL, current leads; E, pure iron electrodes; L, lug ground into stopcock with device for moving upper electrode; PC, purification chamber; M, misch-metal purification arc; VL, voltmeter leads

**Fig. 1. (Above) Apparatus used for the determination of the characteristics of arcs drawn between pure iron electrodes in an atmosphere of argon gas**

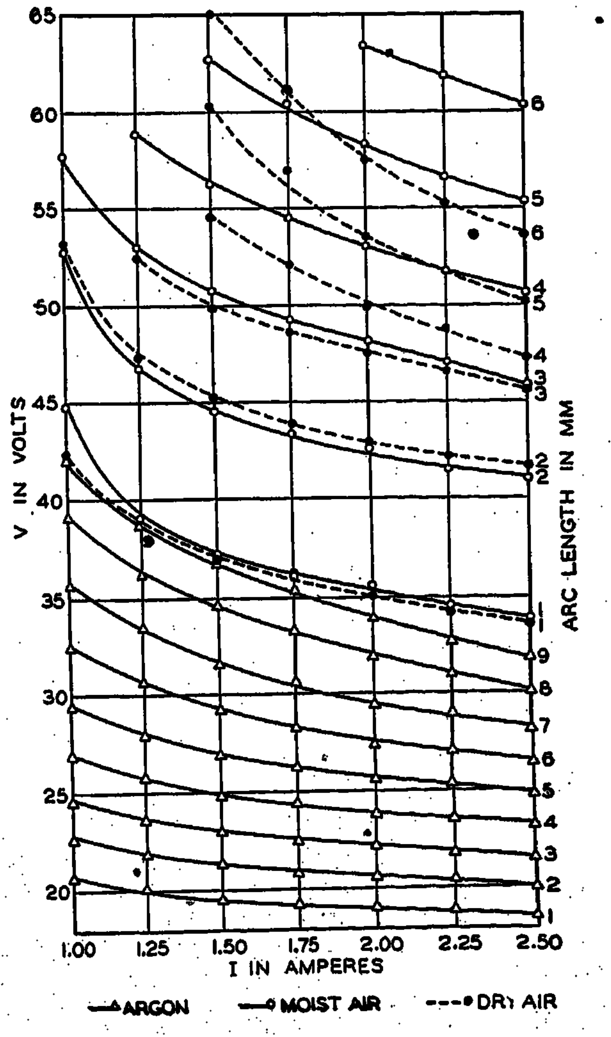

**Fig. 2. (Right) Comparison of the voltampere characteristics of the iron arc in argon gas, moist air, and dry air**

air and those in argon are quite regular. The 1-mm curve in argon is approaching rapidly the condition of constant minimum voltage, independent of arc current.

The arc in argon deposited a black coating on the chamber, probably condensed iron vapor; in air the deposit was of a brownish red color like iron oxid. The arc was difficult to strike at first when new electrodes were used in dry air, but not so in moist air.

Both the arc in argon and in moist air satisfy W. B. Nottingham's equation

$$V = A + \frac{B}{I^n} \text{ with } n = 2.62 \times 10^{-4}T$$

(where $T$ is the boiling point of the anode) as given in the A.I.E.E. JOURNAL for Feb. 1923, p. 302.

## ARC IN DRASTICALLY PURIFIED ARGON

The most astonishing results came when a final drastic purification of the argon as purchased was carried out by circulating it through the misch-metal-arc purification chamber for several hours before the iron electrodes $EE$ were touched. In these runs the greatest care was exercised to obtain absolute cleanliness. An entirely new glass system and new iron electrodes were used each time. All parts (except the iron) were thoroughly baked out in the furnace prior to use. After circulating the argon for several hours (by convection) between the purification chamber and the arc chamber proper, the electrodes $EE$ with a potential of 120 volts across them were touched and slowly separated. In all cases, however slow and cautious the separation, no arc could be struck. It was simply *impossible* to strike an arc between the pure iron electrodes with 120 volts in an atmosphere of *pure* argon.

The implications of this result are far reaching. It has never been supposed previously that an arc required for its establishment a complex atmosphere, or one containing chemically active gases such as the nitrogen and water vapor which constituted most of the 30 parts of impurity in 1,000,000 parts of "impure" argon as received. The low voltage electrical discharge through gas or vapor (i. e., the arc discharge) has been explained by Dr. K. T. Compton (*Phys. Rev.*, v. 21, p. 266, 1923) on the basis of thermionic emission from a hot cathode, and by Dr. Irving Langmuir (*G. E. Rev.*, v. 26, p. 735, 1923; *Science*, v. 58, p. 290, 1923) from the accumulation opposite the cathode of a positive space charge which pulls electrons out of the cathode, whether hot or cold. Most arcs can be accounted for successfully by one or the other theory. Neither theory postulates the necessity for the presence of chemically active atoms or molecules in the arc environment, and yet the refusal of the arc to form in the pure gas used in the experiments here reported indicates this new view. Arcs in argon have been reported frequently in the past, but never in a gas so highly purified as in the present studies. It is possible that our most basic conceptions of the nature of the arc discharge may require modification to conform to these observations of the iron arc in argon.

If the rigorousness of the purification were relaxed in the slightest degree—if, for example, the surfaces of the iron electrodes were not scrupulously cleaned immediately before insertion into the chamber—the normal arc would strike without difficulty; or if the copper grips $CC$ were not baked thoroughly, a discharge between the lower grip (copper) and the upper electrode (iron) about $1^1/_2$ in. long would set in, and after a minute or so return to the electrode tips as a normal iron arc. In the tests which revealed this possible condition apparently enough gas had been liberated from the impure copper grip to support the arc in the then contaminated argon gas. However, when purification was carefully prosecuted and complete it was impossible to strike an arc in any one of the 4 glass systems built.

## HYPOTHESES TO EXPLAIN NON-ARCING

Hypotheses to explain this new characteristic of the arc, at least for the iron arc in argon, were offered following presentation of these results at the 1932 A.I.E.E. winter convention by Dr. K. T. Compton, Dr. Saul Dushman, and Dr. Joseph Slepian. Because of their considerable theoretical interest, these hypotheses are stated in the following paragraphs.

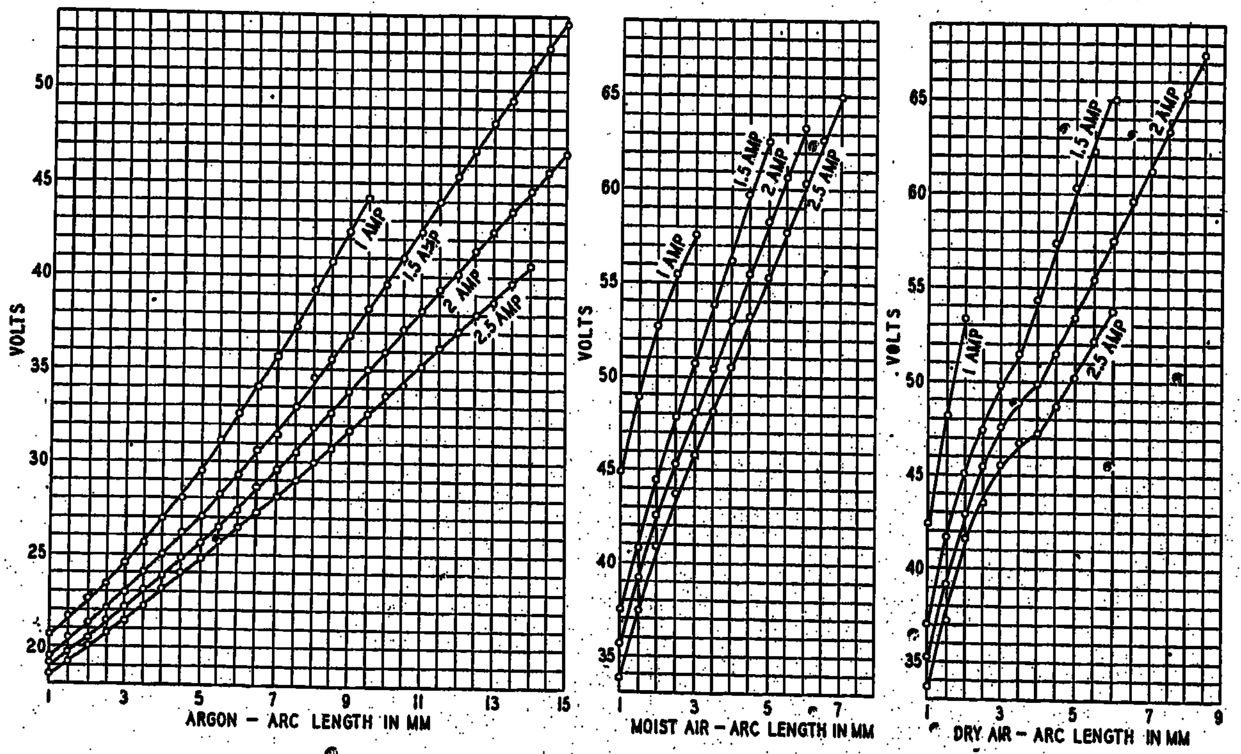

**Fig. 3. Comparison of the voltage-length characteristics of arcs drawn between pure iron electrodes in an atmosphere of argon gas with impurities present (left); in moist air (center); and in dry air (right)**

In commenting on the inability to obtain the normal arc under these "drastically purified" conditions, Dr. Compton in a private communication suggests that possibly an oxid layer on the cathode is a prerequisite in maintaining the proper cathode temperature (in accordance with the thermionic emission theory of the arc). Such an oxid layer might raise the cathode temperature by virtue of its electrical resistance or its thermal insulating properties. Compton further suggests that the elastic electron impacts with argon molecules might so scatter the current over the cathode as to make impossible the establishment of a cathode spot.

Dr. Dushman in a private communication, also considering the arc in terms of thermionic emission, remarks that a thin film of iron on an oxid surface of the metal has a far greater thermionic emission than has the uncontaminated metal surface itself. He is undertaking new experiments in a study of such effects.

Dr. Slepian discussed the subject before the convention in the light of Langmuir's space charge theory. For low current arcs, such as used in the present experiments, the positive space charge just outside the cathode is very small. Consequently, the lines of force of such a charge are spread out so widely that the electric field between the space charge and the cathode is weakened materially. If the field strength drops below a certain value, it is impossible for electrons to be "pulled out" of the cathode, and hence the discharge cannot be supported.

Because of the indicated basic nature of the discovery, these experiments are being continued as part of a comprehensive program, both in America at Lehigh University and abroad in Berlin whence the junior author of this report has gone to continue certain phases of the work. It is contemplated that a complete, detailed report on the studies of the pure iron arc in argon may be published soon by the American Welding Society. Concurrently, the efforts to determine the properties of pure iron welds are being continued; welds of pure iron and also welds of commercial steel have been prepared in "impure" argon and in air. The chemical, physical, mechanical, and metallurgical properties of these welds now are being ascertained.

# Electrical Operation on the Great Northern

**To eliminate a circuitous mountain crossing which had become the "bottle neck" of the line, the Great Northern Railway built a tunnel almost 8 miles long, relocated 17 miles of track, and electrified 73 miles of line. Some of the operating experiences and savings effected in the 3 years since electrical operation was begun are outlined in this article.**

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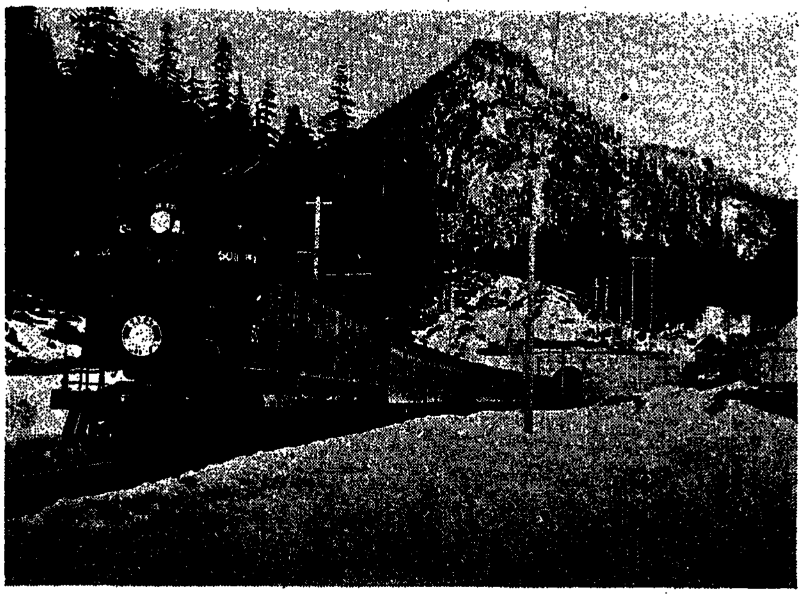

Fig. 1. Locomotive and train leaving western end of new Cascade tunnel

ELECTRIFICATION of the Cascade Division of the Great Northern Railway main line between Skykomish and Wenatchee, Wash., has doubled the capacity of that portion of the line and has resulted in many operating advantages. The electrification, which embraces a total of 73 route miles, was carried out in conjunction with the building of a new tunnel 7.79 miles long, and the relocation of approximately 17 route miles of troublesome track and other minor improvements, aggregating the total expenditure of approximately $25,500,000. All of these improvements were placed in operation at about the same time so that there has been no opportunity to make a direct and segregated comparison of operating expenses that would indicate definitely the advantages of each improvement separately. The new tunnel represented the second undertaking of that nature in the history of the Great Northern Railway's route across the precipitous Cascade range.

The original route, which was placed in operation in 1893, went over the range through Stevens Pass at an elevation of 4,059 ft. It was possible to keep the maximum grade at 2.2 per cent up to 3,382 ft on the

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Essentially full text of a paper "Electrical Operation on the Cascade Division of the Great Northern Railway" (No. 32-110) presented at the A.I.E.E. Pacific Coast convention, August 30–September 2, 1932.

eastern slope, and to el 3,126 ft on the western slope. These points were approximately 2.7 miles apart by direct line through the mountain or 4.5 miles over the pass. A tunnel between these points was considered at the time, but it would have cost more and taken much longer to tunnel than to build the road through the pass, two very important items in those days; consequently the line was built through the pass. This was done by increasing the ruling grade to 4 per cent and resorting to an 8-point switchback, involving approximately 12 miles of track. As had been foreseen, this switchback became the proverbial "bottle neck" of the line and with the natural increase of traffic, its capacity soon was reached. This was particularly so during the winter months when there was apt to be an aggregate fall of from 50 to 100 ft of snow at a rate as high as 8 to 10 in. per hr at times.

To overcome these difficulties and to improve the service, the construction of a 2.63-mile tunnel was begun in 1897. This tunnel which was placed in operation in 1900 ran in a straight line at a constant grade of 1.695 per cent eastbound, cut out the entire switchback, and eliminated 2,332 degrees of curvature and all grades in excess of 2.2 per cent. This improvement shortened the route approximately 9 miles which reduced the running time of all trains about 2 hr with a corresponding decrease in operating expenses.

## First Tunnel Electrified in 1909

With a further increase in traffic the ventilation of this tunnel became so unsatisfactory with the operation of coal burning steam locomotives that the tunnel and tracks at each end were electrified. The 3-phase system was selected for this installation largely because of its ready adaptation to regenerative braking. It was the first and only application of this system in America, as well as the first regenerative braking on a steam railroad. (See "The Electric System of the Great Northern Railway at Cascade Tunnel," C. T. Hutchinson, A.I.E.E. Trans., v. 38, 1909, p. 1281.)

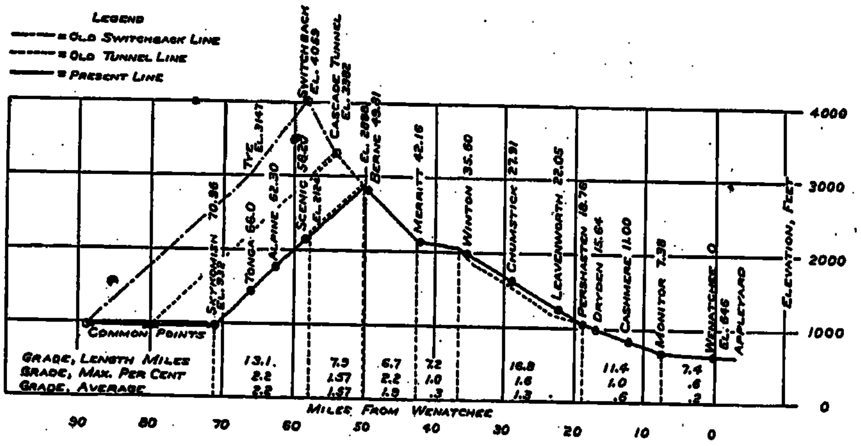


Fig. 2. Condensed profile of the old and new routes over the Cascade range.

Table I—Comparison Between Old and New Lines

| | Old Line | New Line | Advantages of New Line |
|---|---|---|---|
| Length in miles | 17.67 | 9.99 | 7.68 |
| Maximum curve, deg | 10.00 | 6.00 | |
| Total curvature, deg | 2,128 | 187 | 1,941 |
| Maximum grade, % | 2.2 | 2.2 | |
| Tunnel grade, % | 1.695 | 1.565 | |
| Summit elevation, ft | 3,382 | 2,881 | 501 |
| Total rise westward, ft | 546 | 45 | 501 |
| Total fall westward, ft | 1,325 | 824 | 501 |
| Total length of snow shed, miles | 6.04 | | 6.04 |
| Total length bridges, miles | 0.23 | 0.04 | 0.19 |
| Total length tunnels, miles | 3.66 | 7.79 | |

Electrical operation of this tunnel was begun in July 1909. The 3-phase equipment satisfactorily met the original requirements and was continued in service until March 1927 when it was replaced by the present single-phase system. The only notable modification of the 3-phase equipment was the installation of the necessary wiring and switches for a concatenated connection of the traction motors to provide a running speed of $7^1/_2$ mph in addition to the speed of 15 mph originally selected. This was done in the latter part of 1923 when the division point of the road was removed from Leavenworth to Wenatchee (Appleyard) which increased the length of the freight run from 109.3 miles to approximately 132 miles.

At the beginning of electrical operation, the freight trains did not exceed 1,600 tons trailing so that 3 of the 115-ton electric units were used to take this train with the road steam locomotives through the tunnel at one trip. With a gradual increase in train weights it had been found necessary to cut the heavier trains and take them through in 2 trips on account of the limited capacity of the Tumwater power plant; this caused a delay of about an hour. By using the half-speed connection it was possible to use 4 electric units per train and to haul up to 2,200 tons trailing plus the steam road locomotives through the tunnel at a single trip without exceeding the capacity of the power plant.

## Electrification Extended

This lessening of the total number of trips per day left the electric locomotive crews and the power plant idle a greater portion of the time. Consequently consideration soon was given to the extension of the electrification from the west portal of the tunnel to Skykomish, a distance of approximately 21 miles, so that the electric units might be used to replace the steam locomotives used in the helper service on the 2.2 per cent grade up the west slope. A study of this plan indicated that, if adopted, quite a saving in operating expenses should result in addition to some saving in time. There would be practically no increase for electrical operating cost as the extended service would increase only the load factor without adding greatly to the crew hours paid for, and the necessity for the stop at the west portal of the tunnel would be avoided.

In the consideration of this extension it was realized that a new tunnel undoubtedly would be constructed within a few years, involving a new route which would result in the abandonment of at least 9 miles of this proposed extension as well as the old tunnel electrification. It was necessary therefore that the expenditure for the extension be kept at a minimum and that any additional electric locomotives required be capable of use on any desired change of route.

The 3-phase locomotives then in use in the tunnel with their constant speed characteristics and with only 2 operating speeds were not best suited to meet operating conditions on the extension. This fact, together with the complications in the contact system owing to the necessity for the 2 overhead wires, made it unlikely that this system would be chosen if the electrification were extended beyond the mountain section. After careful consideration the single-phase motor-generator type of locomotive was chosen as being best suited to meet all of the existing conditions. This locomotive embodies a combination of the most desirable features of both single-phase and d-c locomotives. The speed can be varied to any degree necessary to conform to either the train weight or available power, or both; this type of locomotive thus is well adapted to operation as a helper to a steam locomotive. For the extension planned, one double-unit class 1 — D — 1 + 1 — D — 1 motor-generator locomotive originally was ordered.

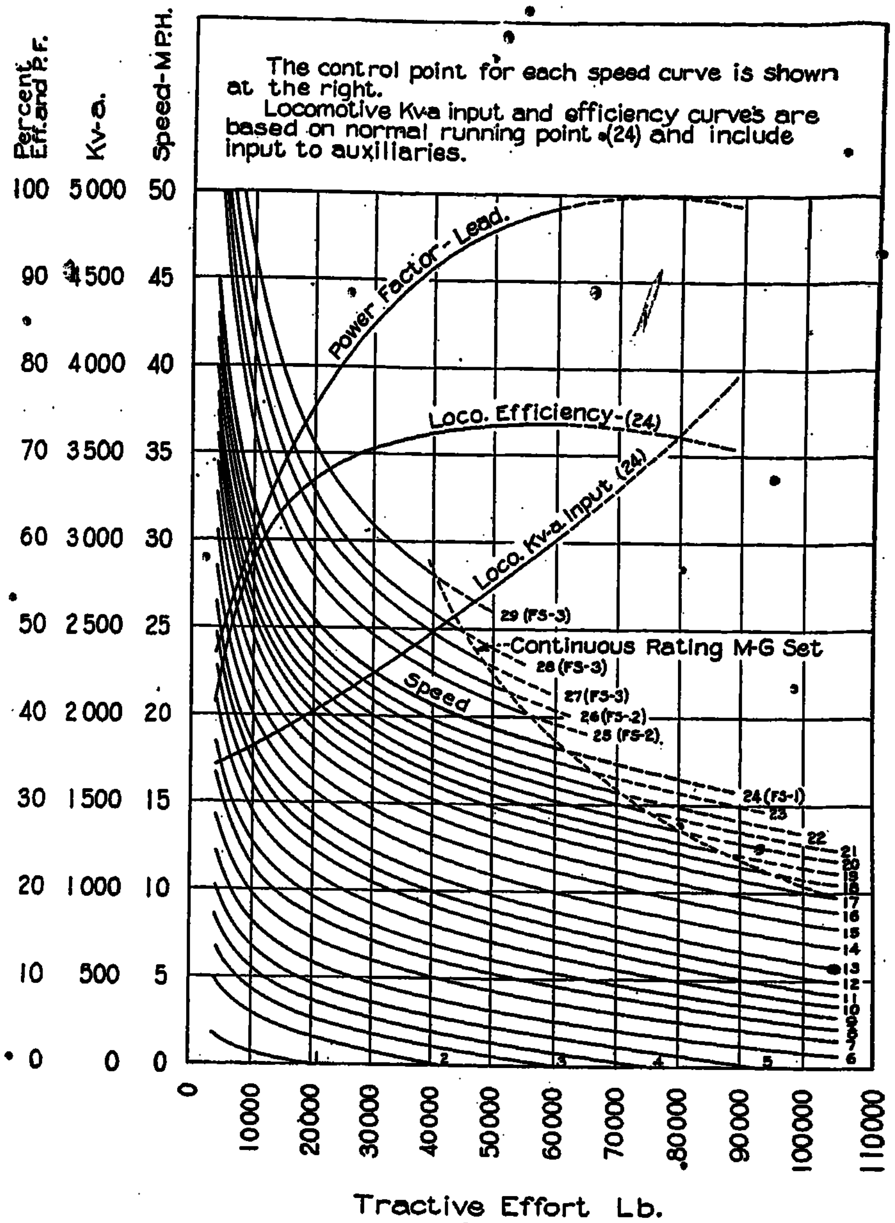
Generators at the power house were of liberal design, having sufficient excess capacity over the water-wheels to permit their operation single-phase. Available capacity at the power house was approximately 4,000 kw.

## NEW TUNNEL AND FURTHER ELECTRIFICATION

A few months after the equipment for this extension had been ordered and before electrification had been completed, a decision was reached to construct a new tunnel 7.79 miles in length. The new route would leave the main line at Scenic on the west slope and join it again at Berne on the east slope, thus substituting 9.99 miles of new route for 17.67 miles of the old route with advantages as indicated in Table I.

The new line would remain below the elevation of heaviest snowfall and would traverse a route less subject to drifts and slides than was the old route. Also a relocation of the line between Winton and Peshastin had been surveyed which would (1) avoid some troublesome line in the Tumwater Canyon; (2) reduce the maximum grade from 2.2 per cent to 1.6 per cent, the maximum curve from 10° to 3°, and the total curvature 1,286°; and (3) shorten the line about $1^1/_4$ miles.

With these revisions of line in view and with a further definite decision to electrify the entire line between Skykomish and Wenatchee and to leave off the steam locomotives between these points, the character of the service was so changed as to make it desirable to consider some revision in the additional motive power required. Between Merritt and Wenatchee over the new route, a distance of 42 miles, the line would permit speeds of 50 mph safely, whereas the line between Skykomish and Cascade Tunnel did not permit speeds in excess of 30 to 35 mph; the new locomotives (class 1 — D — 1 + 1 — D — 1) had been designed accordingly with a maximum safe speed of 40 mph. With only 73 route miles electrified requiring so few locomotives, it was desirable to have all locomotives interchangeable between passenger and freight service and that any locomotive be operatable in the same train with any other locomotive. Regular passenger trains operated over the line varied from 8 to 12 cars, aggregating from 700 to 1,000 trailing tons; freight trains ordinarily would range between 2,500 and 4,000 tons trailing. Grades range from 0.2 to 2.2 per cent, the average up grade for the line being approximately 1.29 per cent (see Fig. 2).


The control point for each speed curve is shown at the right.

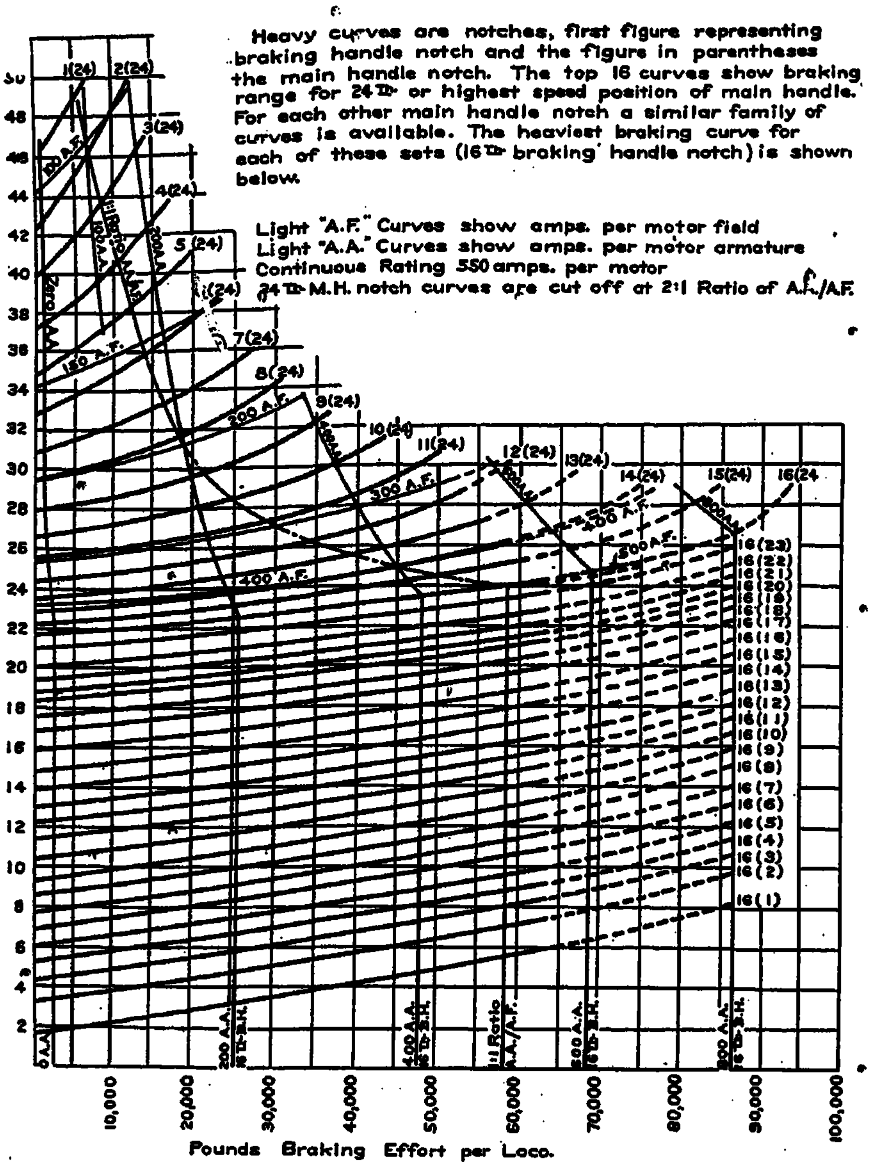
Locomotive Kv-a input and efficiency curves are based on normal running point (24) and include input to auxiliaries.

**Fig. 3. Characteristic motoring curves of the 1 — C + C — 1 10,500-volt 25-cycle locomotive**

## NEW LOCOMOTIVES DESIGNED

To meet these new conditions, a new locomotive known as class 1 — C + C — 1 was proposed, pertinent data for which are given in Table II in comparison with the double unit locomotive (class 1 — D — 1 + 1 — D — 1) for the extension from Cascade Tunnel to Skykomish.

Class 1 — C + C — 1 locomotives, designed particularly for mixed service over the new line, will handle a 1,000-ton trailing train at 18.5 mph on the 2.2 per cent grade and up to about 45 mph on the 0.2 per cent, averaging over the entire up grade portion about 28.6 mph, the average output of the motors being approximately 2,100 kw and the rated load factor, 84 per cent. On the down grades the speed is limited to a maximum of 50 mph. Regenerative features of the locomotive provide satisfactory control of the speed on the varying down grades to meet any conditions imposed by curvature, track conditions, or schedule requirements. Figs. 3



Heavy curves are notches, first figure representing braking handle notch and the figure in parentheses the main handle notch. The top 16 curves show braking range for 24th or highest speed position of main handle. For each other main handle notch a similar family of curves is available. The heaviest braking curve for each of these sets (16th braking handle notch) is shown below.

Light "A.F." Curves show amps. per motor field
Light "A.A." Curves show amps. per motor armature
Continuous Rating 550 amps. per motor
24th M.H. notch curves are cut off at 2:1 Ratio of A.A./A.F.

Fig. 4. Characteristic braking curves of the 1 — C + C — 1 10,500-volt 25-cycle locomotive

and 4 give, respectively, the motoring and braking characteristics of this locomotive.

Of the 1 — D + D — 1 locomotives 2 were placed in the Skykomish-Cascade tunnel service in March 1927, 2 in the fall of 1928, and 1 early in 1929. The 5 locomotives of this class thus have been in service for the equivalent of about 23 locomotive years. Two of the 1 — C + C — 1 locomotives were placed in the Skykomish-Cascade tunnel service in September 1927, 2 others a year later and 4 were ordered in October 1929, 9 months after the complete electrification had been placed in operation. These locomotives now have been in service about 2 years so that the 8 units of this class have been in service the equivalent of 25 locomotive years.

Of this grand total of 48 locomotive years, approximately 9 years were in the service between Skykomish and Cascade Tunnel as originally planned. This service consisted of helping the regular steam locomotive up the 2.2 per cent grade to the entrance of the tunnel, through which the grade was reduced to 1.695 per cent, making it possible to shut off the steam while in the tunnel.

During 1927–1928, freight trains, ranging from 2,500 to 3,500 tons trailing, were brought to Skykomish by 2 steam locomotives. There, the rear steam locomotive was dropped off and replaced by 2 electric locomotives, one ahead of the steam road engine and one in the rear of the train. In the beginning, the rear locomotive was put at the extreme ends of the trains, but later it was found to be safer to place the rear unit about half to two-thirds back in the length of the train to prevent possible buckling of the train at some weak spot. These heavy freight trains were taken from Skykomish to Cascade tunnel, 25 miles, in $1^3/_4$ hours whereas with steam operation from 4 to 5 hours usually were required. On passenger trains, one electric locomotive was placed ahead of the steam locomotive to help propel the train, in accordance with requirements, to the entrance of the tunnel through which the electric locomotive hauled the train and engine unaided. This operation was begun in March 1927 and continued until the opening of the new tunnel January 12, 1929.

Wenatchee being a division point, all engines and crews of both passenger and freight trains are changed on arrival there. On arrival of all trains at Skykomish from the west, the engine crews shift from the steam locomotives to the electric and continue the trip to Wenatchee; all westbound engine crews similarly transfer from the electric to the steam locomotives and continue to Seattle.

## Early Operating Troubles in New Tunnel

The first 10 days of electrical operation over the new route through the new tunnel was without serious incident. On 2 occasions before the opening of the tunnel, there had been instances of arcing to ground from terminals of current transformers while locomotives were standing inside the new tunnel near the east portal. However, no serious damage resulted.

On one occasion in the old tunnel a transformer had been lost and an arcover at current transformer terminals on 2 locomotives had occurred in zero weather during the first winter after electrical operation began there. A frequency changer set used in connection with the work on the new tunnel had burned out and other disturbances on the line had occurred on the same day, so it was thought these troubles were due to surges. Additional insulation was installed on the terminals and transformers where the trouble seemed to have originated and no further trouble occurred. Therefore when arcovers began to occur in the new tunnel, steps were taken immediately to have 3 surge recorders placed on the trolley circuit, one at each end of the tunnel and one midway between. A fourth recorder was placed on a locomotive running over the entire line. These had just been installed when sub-zero weather arrived and more serious troubles began.

Within less than a week 4 locomotive transformers burned out and several arcovers occurred from terminals of current transformers to ground. In every instance, these troubles occurred on a locomotive attached to a freight train westbound through the tunnel. No trouble was experienced on locomotives hauling passenger trains nor on locomotives eastbound hauling freight trains. The loss of 4 out of a total of 14 main transformers within a week was alarming and even seriously threatened the possibility of continuing to handle all of the traffic over the line electrically.

The surge recorders were left on the circuit from 3 to 4 weeks, during which time there were arcovers and burnouts of transformers. A careful examination of all the records, however, failed to indicate that there had been any surges registered higher than about 2 times normal voltage. This being well within the limits ordinarily expected from necessary switching operations, surges were eliminated from responsibility for the trouble.

## TROUBLES DUE TO CONDENSATION

When the temperature outside the tunnel was below freezing, some signs of condensation had been noted on the outside of the locomotive cab and on the inside near the air intakes. This condensation increased as the temperature outside approached zero. The east end of the new tunnel is at about 634 ft greater elevation than the west end and this, together with the piston action of the moving trains, afforded satisfactory ventilation ordinarily, but it was found that the temperature of the air in the tunnel near the middle varied only between 50 and 65 deg F irrespective of the outside temperature (see Fig. 5). Since the draft was toward the east portal, the rise in temperature entering the tunnel from that end was much more rapid than from the west end. To add to the difficulties, the outside temperature on the east side of the mountain usually was lower than on the west side.

A locomotive starting from Wenatchee with normal ventilation, when the outside temperature was below zero, would show little rise in temperature by the time it had reached the east portal of the tunnel so that immediately after entering the tunnel and encountering the much warmer air, frost began to collect on the outside of the cab and truck; within 2 or 3 minutes, the locomotive was coated thickly with frost crystals, the accumulation of which continued until the locomotive began to warm up when this frost would become liquid and begin to drop off. The same action took place inside the locomotive but to a lesser extent.

At times, when the moisture precipitation was greatest, corona was observed on the 11-kv circuit, particularly at taped joints and terminals. It was no doubt the corona at the surface of the heavily taped terminals connecting the current transformers on the 11-kv circuit to the primary of the locomotive transformer that caused the arcovers to ground at this point.

The moisture condition was aggravated by the large volume of air drawn into the locomotive by the blowers for cooling the electrical equipment. The outside temperature east of the tunnel varies from around 100 deg F in summer to 15 deg below zero during winter, making it necessary to supply as much as 40,000 cu ft of air per minute during the hottest weather.

Experiences with other locomotives requiring much less ventilating air had indicated conclusively that during rain or snow storms dangerous quantities of moisture would be carried inside the locomotives by this large volume of air. To protect the electrical equipment from this danger the louvers for the 1 — C — C — 1 locomotives had been provided at the factory with adjustable shutters by means of which the openings for air intake could be varied from fully open to fully closed. In order to insure proper ventilation of the apparatus when the louvers were closed, dampers were placed in the outlets for the air from the apparatus to direct the air back into the locomotive for recirculation through the apparatus, thus replacing the moisture-bearing air from the outside.

## TROUBLE CURED BY CLOSING VENTILATING LOUVERS

While it had not been foreseen that there would be so great a variation between the temperature outside and inside the tunnel as to cause serious trouble, these provisions for closing the louvers and recirculating the inside air were readily applicable to overcoming this unexpected danger. By closing the louvers and adjusting the dampers at the beginning of a trip the air inside the locomotive was raised easily to a temperature so nearly approaching that of the air inside the tunnel as to prevent any harmful precipitation of moisture. When weather conditions are such as to require the closing of the louvers the temperature outside is never at a maximum so that recirculation of the inside air does not cause excessive heating of the apparatus.

Since operation with closed louvers was begun, the electric locomotives have operated through 3 winters without any trouble from condensation. Moreover, this trouble from condensation is the only serious difficulty that has been experienced in the operation of the electrified line.

## COST DATA AND COMPARISONS

Motor-generator locomotives are well adapted to service where the freight trains may vary from 2,500

**Table II—Comparison Between the 2 Types of Motor-Generator Locomotives in Use**

| | | |
|---|---|---|
| Classification | 1−C+C−1 | 1−D+1+1−D−1 |
| Total weight, lb | 539,000 | 715,400 |
| Weight on drivers, lb | 426,200 | 550,000 |
| No. of driving axles | 6 | 8 |
| Weight per driving axle, lb | 71,030 | 68,750 |
| Weight on guiding axles, lb | 112,800 | 165,400 |
| Weight per guiding axle, lb | 56,400 | 41,350 |
| Length over couplers | 73 ft. 9 in. | 94 ft. 4 in. |
| Total wheel base | 58 ft. 8 in. | 78 ft. 11 in. |
| Rigid wheel base | 15 ft. 4 in. | 16 ft. 9 in. |
| Height, pantograph down | 15 ft. 3 in. | 15 ft. 10 in. |
| No. traction motors | 6 | 8 |
| Tractive effort continuous rating, lb | 60,500 | 88,500 |
| Tractive effort 30% adhesion, lb | 127,860 | 165,000 |
| Speed at continuous rating, mph | 18.6 | 15.5 |
| Maximum safe speed, mph | 50 | 40 |
| No. ordered | 8 | 5 |
| Transformer, secondary volts | 2,300 | 1,100 |

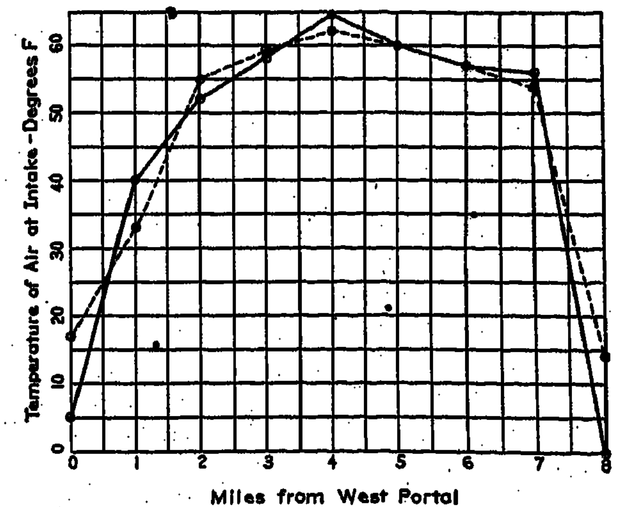


Fig. 5. Curves showing typical temperature variation in the new Cascade tunnel during near-zero weather

to 5,000 tons trailing and where it is desirable to limit the maximum power demand to the most economical point. However, the first cost of this locomotive and its weight per horsepower is apt to be greater and its over-all efficiency somewhat less than of other types. The maintenance cost of these locomotives during the 3 years 1928-30 has been 28.66 cents per locomotive mile, or 13.65 cents per 100 tons on drivers. A comparison of these costs with those of 3 other electrified roads using locomotives in similar service with regenerative braking on heavy grades is as follows:

| | Locomotive Miles | Per Locomotive Mile | Per 100 Tons on Drivers |
|---|---|---|---|
| Chicago, Milwaukee, St. P. & P. | 7,939,539 | 14.20c | 6.92c |
| Norfolk & Western | 1,520,608 | 46.82 | 17.60 |
| Virginian | 1,562,574 | 48.49 | 12.26 |
| Great Northern | 937,492 | 28.66 | 13.65 |

A direct comparison of operating expenses between steam and electric operation is impossible for the reason that the route now being operated electrically never has been operated by steam. Furthermore, the shortening of the route and the reduction of elevation by the new tunnel have had important parts in reducing the operating expenses.

However, early in 1920, a study of the old line was made with a view to electrification. In this study operating data and costs were carefully prepared covering 12 months ending September 30, 1919 for steam operation between Skykomish and Wenatchee through the old tunnel. These data are still available for comparison with corresponding costs covering the year 1929, with electrical operation over the new line. Table III shows a comparison of those items of operating expense vitally affected by electrical operation for the 2 years mentioned.

## Table III—Comparison of Steam and Electric Operating Costs

| | Steam | Electric | Difference Amount | Difference % of Steam |
|---|---|---|---|---|
| Route miles | 80 | 73 | 7 | 8.8 |
| Locomotive miles | 767,151 | 406,910 | 360,241 | 47.0 |
| 1,000 ton miles | 485,000 | 408,108 | 76,892 | 15.8 |
| Train miles | 607,000 | 292,930 | 314,070 | 51.7 |
| Costs— | | | | |
| Enginemen | $ 276,597 | $ 80,049 | $196,548 | 71.0 |
| Trainmen | 175,819 | 77,413 | 98,406 | 56.0 |
| Fuel or power | 659,850 | 269,298 | 390,552 | 59.2 |
| Locomotive repairs | 243,114 | 109,085 | 134,029 | 55.1 |
| Enginehouse | 67,260 | 22,885 | 44,375 | 66.0 |
| Lubricants | 3,325 | 5,525 | +2,200 | 66.2 |
| Supplies | 3,414 | 1,643 | 1,771 | 51.9 |
| Water | 1,308 | | 1,308 | 100.0 |
| Substations | 5,543 | 5,995 | +452 | 8.2 |
| Distribution | 3,411 | 41,917 | +38,506 | 1128.9 |
| Total | $1,439,641 | $613,810 | $825,831 | 57.3 |
| Avg. cost per 1,000 ton miles | 2.968 | 1.504 | 1.464 | 49.3 |
| Avg. cost per train mile | 2.372 | 2.095 | 0.277 | 11.7 |
| Avg. tons per train, freight | 1,882 | 3,021 | 1,139 | 60.5 |
| Avg. tons per train, passenger | 494 | 568 | 74 | 15.0 |
| Avg. road time, freight | 13.4 | 5.5 | 7.9 | 59.0 |
| Avg. road time, passenger | 4.1 | 2.8 | 1.3 | 31.7 |
| Avg. mph, freight | 6.0 | 12.9 | 6.9 | 115.0 |
| Avg. mph, passenger | 19.4 | 25.5 | 6.1 | 31.4 |

PROPORTIONED BETWEEN FREIGHT AND PASSENGER SERVICE

| | Steam Freight | Steam Passenger | Electric Freight | Electric Passenger |
|---|---|---|---|---|
| Locomotive miles | 466,428 | 300,723 | 199,806 | 207,104 |
| Train miles | 207,286 | 399,720 | 98,478 | 194,452 |
| 1,000 ton miles | 390,000 | 95,000 | 297,550 | 110,558 |
| Total cost, items affected | $1,067,641 | $372,000 | $391,810 | $222,000 |

The total cost of the improvements involved in building the new line and the electrification was, in round numbers, $25,500,000 made up as follows:

| | |
|---|---|
| 7.79 miles tunnel complete | $14,000,000 |
| 17.0 miles new track | 5,000,000 |
| 73 miles electrification | 6,500,000 |

Segregated costs of the electrification were approximately as shown in Table IV.

In reviewing the study made in 1920 relative to the electrification of the old line for comparison with the present electrification, it was interesting to find an estimate of the cost of the proposed electrification of 80 miles of line between Leavenworth and Gold Bar through the old tunnel and which would require the same electrical equipment as the present electrification. The estimated cost of the complete electrification at that time was $6,463,750, or $80,800 per route mile; of this amount, $3,250,000 or 50.28 per cent, was for electric locomotives. Savings from electrical operation estimated for items affected were $639,703.

## Table IV—Itemized Cost of the Skykomish-Wenatchee Electrification*

| | Amount | Per Route Mile | Per Cent of Total: Less Locomotives | Per Cent of Total: With Locomotives |
|---|---|---|---|---|
| Substations, etc. | $1,062,611 | $14,556 | 33.63 | 16.21 |
| Transmission system | 531,967 | 7,287 | 16.70 | 8.12 |
| Power distribution | 368,040 | 5,042 | 11.56 | 5.62 |
| Poles and fixtures | 567,265 | 7,771 | 17.81 | 8.66 |
| Telephone and telegraph changes | 157,440 | 2,157 | 4.94 | 2.40 |
| Signals and interlocks | 155,970 | 2,136 | 4.90 | 2.38 |
| Shops, machinery, tools | 138,357 | 1,895 | 4.34 | 2.11 |
| Engineering | 203,512 | 2,788 | 6.39 | 3.10 |
| Total less locomotives | $3,185,162 | $43,632 | 100.00 | 48.60 |
| Locomotives | $3,368,338 | $46,141 | | 51.40 |
| Total | $6,553,500 | $89,773 | | 100.00 |

* $174,604 credit deducted for 14 miles of electrified line abandoned. Route miles 73; track miles 91.

While a large portion of the savings shown in Table III favorable to electrical operation is due to the new tunnel, this improvement would not have been practical without electrical operation. The decision to build the tunnel was reached only after a careful report had been prepared which indicated that interest on the capital charge would be covered easily by the saving in like charges for new snow shed construction and in maintenance charges for these sheds in the future, thus putting the investment for the new tunnel on a self-supporting basis.

Saving in operating expense shown in Table III is equal to 12.63 per cent on the gross cost of the electrification which, together with the shortened time and other improvements in the service, makes the electrification a favorable investment with a normal volume of traffic. The electrical equipment is easily capable of handling an increase of 50 per cent in the freight traffic and with such an increase, the saving in operating expenses would be in about the same proportion, making the return on the gross investment for electrification approximately 18 per cent.

Capacity of this portion of the line which, with a congestion of traffic, undoubtedly would become the bottle neck of the system with steam operation has been increased 100 per cent as is indicated by the records. These records show that whereas with steam operation in 1920, 3 steam locomotives averaged approximately 6 hours to take a 2,250-ton train the 24.3 miles from Skykomish to the old summit, in 1929 2 electric locomotives averaged about $1^1/_2$ hours to take a 5,000-ton train the 21.2 miles from Skykomish to the new summit. In ton miles per train hour, this is 70,666 for the electric as against 9,112 for steam, a ratio of 7.7 to 1 in favor of electrical operation.

# Distribution System Lightning Protection;

## Interconnection of Primary Arrester Ground and Secondary Neutral

**Although distribution transformers have high impulse strength compared to their normal voltage ratings, they still flash over and fail in service even when protected by arresters. Interconnecting the ground lead of the primary arrester with the transformer secondary neutral limits the voltage across the transformer insulation to that permitted by the arrester alone, and introduces no additional hazard on the low voltage circuit where secondary neutral ground resistances are low. This is the first group of articles dealing with the subject of protecting distribution systems from lightning; articles dealing with other phases of the problem will appear subsequently in ELECTRICAL ENGINEERING.**

LIGHTNING SURGES in ordinary urban distribution circuits manifest themselves in a manner somewhat different from that of those occurring on high voltage transmission lines. In the distribution circuit the arrester spacing usually is such that the distance traveled by the voltage wave will be short, the crest voltage appearing on the line will be limited, and the surge will manifest itself as current through one or more arresters. The current wave, both as regards magnitude and shape, is determined largely by the lightning stroke and but little by the characteristics of the distribution circuits. On rural lines the exposure between arresters is much greater, so that in addition to surges originating near the arrester there are surges arriving over a length of line. Crest voltages of these surges are limited by the line insulation.

Experience has shown that although failures of distribution transformers and the blowing of fuses during lightning storms are reduced greatly by the application of lightning arresters, the record of protection is not so good as the strength of the transformer and performance data of the arrester would indicate it should be. In general, the ratio between the strength of the transformer insulation and the voltage allowed by the arrester is not far from 4 to 1. With such a large margin, failures of transformers or fuse blowing due to lightning should be practically eliminated except in the case of a direct stroke at the transformer location, a relatively infrequent source of trouble.

Protection now commonly employed for distribution transformers provides for phase and neutral arresters on the primary side of the transformer. With few exceptions these arresters are connected to a common ground lead which in turn is connected to a driven ground rod at the base of the pole. This arrangement is based upon the supposition that lightning surges entering over the primary conductors would pass to ground, and that the arrester would hold the primary winding to a potential equal to the arrester discharge voltage. Unhappily, this condition does not hold in practice because arrester ground resistances are not zero, but may be as high as several hundred ohms. Furthermore, the exposure of secondary circuits in urban districts may exceed by far the exposure of primary circuits there; hence lightning surges frequently enter on the secondary conductors when primary arresters connected in accordance with present practise are not in position to be of service.

From the foregoing it is clear that several factors may prevent the primary arresters from properly protecting the distribution circuits. Connecting the arrester ground to the grounded secondary neutral, however, appears to eliminate many of the disturbing factors. With such a connection the voltage between the transformer windings under impulse conditions will not exceed the potential allowed by the arrester; this potential is low enough for transformer failures from bushing flashovers to be practically eliminated. With this idea in mind several investigations have been conducted in various parts of the country; 3 of these are covered in the following 3 articles. The first, by Opsahl, Brooks, and Southgate, includes a theoretical study and laboratory tests made to determine the effectiveness of interconnecting in different ways the primary arrester ground and the secondary neutral. The second article, by Harding and Sprague, covers tests made on an experimental line built in accordance with standard construction practise of the Commonwealth Edison Company of Chicago. The third article, by McEachron and Saxon, describes tests made on an actual distribution line built to serve a small rural community in central New York.

From the investigations conducted, the information presented in these articles indicates that much greater protection to distribution transformers is effected through interconnecting the primary arrester ground with the grounded secondary neutral than through present protection schemes. Further, it is shown that this interconnection introduces no additional hazard in the low voltage circuit except where the secondary neutral ground resistance is high.

# I—Theoretical Studies and Laboratory Tests

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TESTS show that when a surge is applied to the primary of a distribution transformer that has a secondary ground, the isolated case will assume a low electrostatic potential above ground so that about from 80 to 95 per cent of the surge voltage will appear from primary lead to case. For simplicity in the considerations that follow, it will be assumed that the case potential under these conditions is the same as that of the secondary neutral.

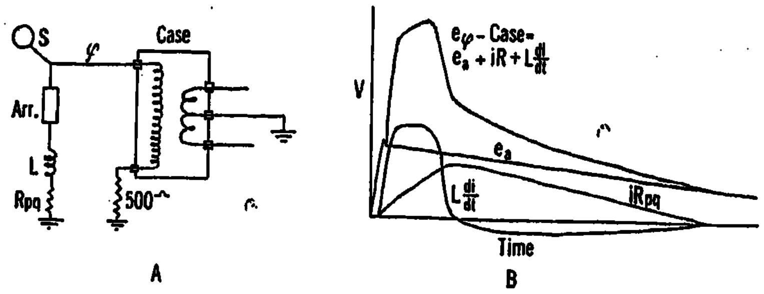

Fig. 1. Lightning surge voltage across the bushings of a distribution transformer protected in accordance with present practise

Potential across a transformer when a surge is applied, as shown in Fig. 1, is the total of 3 components: the *IR* drop across the ground, the inductive drop across the ground lead, and the voltage across the arrester. The *IR* drop across the ground is proportional to the current in the surge, while the drop across the lead is proportional to the rate of rise of current. For anticipated surge currents the voltage across the ground alone can exceed the voltage across the arrester, unless the ground resistance is very low.

With present methods of installation, voltages appearing across the primary bushings often are great enough to cause flashovers; the completed path for the surge current to ground usually is over the secondary bushings. The usual sequence of events during a flashover and the voltages which occur are shown in Fig. 2. Primary bushing flashover takes place at a time $t_1$, and secondary bushing flashover almost simultaneously at a time $t_2$. If the transformer be connected to the power circuit the flashover path will carry the power arc until the primary fuse opens the circuit. In service this is the path over which the arc burns usually are found. Under these conditions both the surge current and the power follow current flow through the secondary neutral ground, but operating experience indicates no serious trouble on the customer's property.

## INTERCONNECTION OF PRIMARY ARRESTER GROUND AND SECONDARY NEUTRAL

By interconnecting at the transformer the arrester ground and the transformer secondary neutral, the potential difference across the primary bushings of the transformer will be limited to the voltage permitted by the arrester alone during a discharge, in accordance with the prior assumption that the secondary neutral and case remain at the same potential. In Fig. 3 is shown the effect of this interconnection where the assumed secondary neutral impedance to ground is small. Whether this secondary impedance be low or high, the potential across the primary bushing will not be greater than that permitted by the arrester alone. Under these conditions the transformer will not flash over and there will be no power current flowing from the primary circuit into the secondary neutral. Whatever impedance drop there is from the surge current flowing in the secondary neutral of course will appear as voltage in that circuit.

If a solid connection is not permissible between the secondary neutral and the ground terminal of the primary arrester, a gap or valve arrester of low voltage rating may be placed in the interconnection

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Based upon "Lightning Protection for Distribution Transformers" (No. 32-18) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25-29, 1932.

as shown in Fig. 4A. This arrester will begin passing current when the voltage across the ground lead becomes great enough to discharge the arrester. In this case the voltage across the primary bushing is the sum of the voltages appearing across the primary and interconnecting arresters as shown in Fig. 4B. This connection will isolate effectively the arrester ground and the secondary neutral, as there is no potential difference between them except during a surge discharge.

A second method of obtaining the improved protection afforded by the interconnection without connecting a solid conductor between the arrester ground and the secondary neutral, is that shown in Fig. 5. Where the effective leakage reactance between the 2 halves of the secondary winding is small, the surge current in flowing as indicated will result in a low voltage across the winding as the magnetic effects of the 2 currents are in opposition.

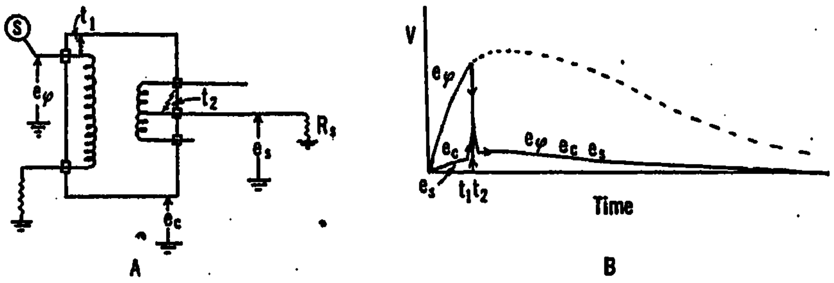

**Fig. 2. Voltage-time relation as a flashover occurs on a distribution transformer from a surge applied to the primary**

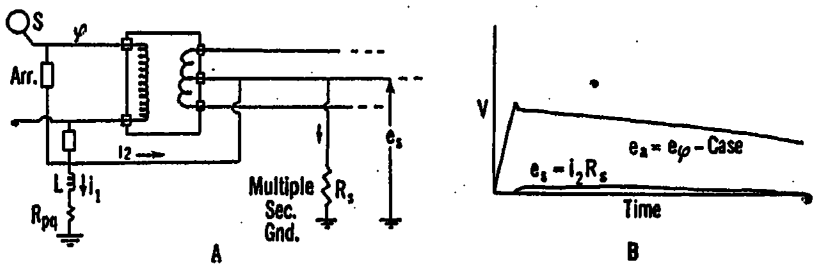

**Fig. 3. Voltage across transformer bushings with primary arrester ground lead interconnected to secondary neutral; surge applied to primary**

This circuit was proposed by C. B. Wright of the Duquesne Light Company (Pittsburgh, Pa.) and has shown very promising results in laboratory tests.

At present the safety code in most localities forbids the interconnection of the primary arrester and the secondary neutral grounds. This regulation was made in recognition of the fact that when a surge current flows through a ground a surge voltage appears across it. The driven grounds which were assumed when the regulation was adopted usually have a much higher resistance than the water pipe grounds ordinarily used at the present time.

### Limitations of the Interconnection

Where both primary arrester and secondary neutral grounds are driven grounds, as in the case of a rural customer, the interconnection can prevent flashover across the transformer insulation, but an appreciable surge voltage may appear from secondary to ground. This condition is less serious than permitting a power fault in the secondary circuit, but the resistance of both grounds should be made as low as possible so that the surge $IR$ drop may be low.

The ungrounded secondary is not common practise in distribution circuits; where it is used, a surge on the transformer primary will give the secondary circuit a potential above ground and the smaller the capacity of the secondary to ground, the greater will be its potential. Obviously an interconnection of a poor primary ground with the free secondary will not lower the voltage across the arrester ground appreciably, and flashovers from secondary to ground would be expected.

### Tests on a Typical Distribution Circuit

To determine the magnitude of the effects required to cause flashovers similar to those that have occurred in service, a program of tests was carried through. A diagram of the test circuit is shown in Fig. 6. The distribution transformer shown was mounted on a 35-ft pole. A ground lead was provided down the pole and in order to obtain low ground resistance, 2 ground rods were driven at the foot of the pole. The secondary wires were racked for about 140 ft. From the transformer pole and from the end of the secondary rack triplex services were run to a point on the ground where the neutral wires were solidly grounded. One wire of each triplex service was left open, as indicated in Fig. 6 by "open service." One service wire and the neutral from each service were connected to a 100-ft section of 2-conductor metal-armored BX cable, both ends of the armor being grounded. The 2 sections of BX cable were connected to the same 2 secondary wires.

In the tests as made, flashovers were necessary in order to simulate conditions that obtain in practise.

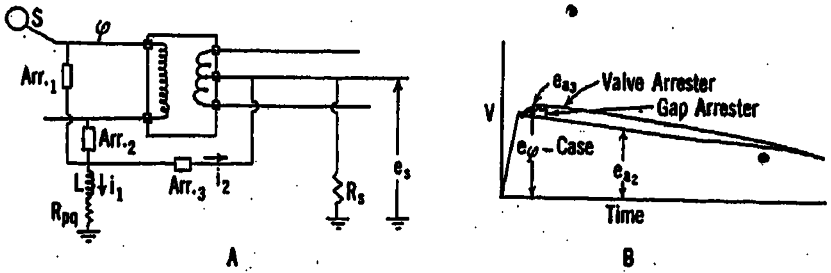

**Fig. 4. Surge voltages across transformer bushings with primary arrester ground connected to secondary neutral through low voltage arrester; surge applied to primary**

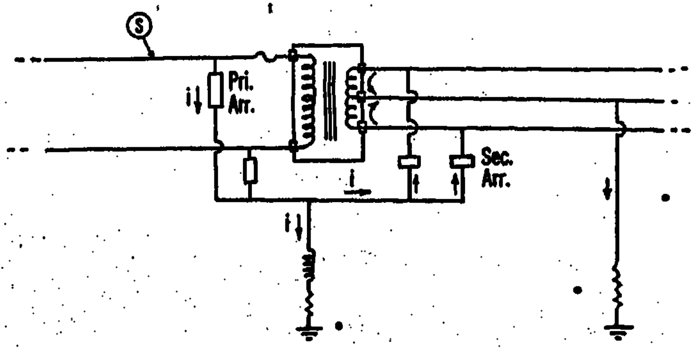

**Fig. 5. Primary arrester ground connected to transformer secondary leads through secondary arresters; surge applied to primary**

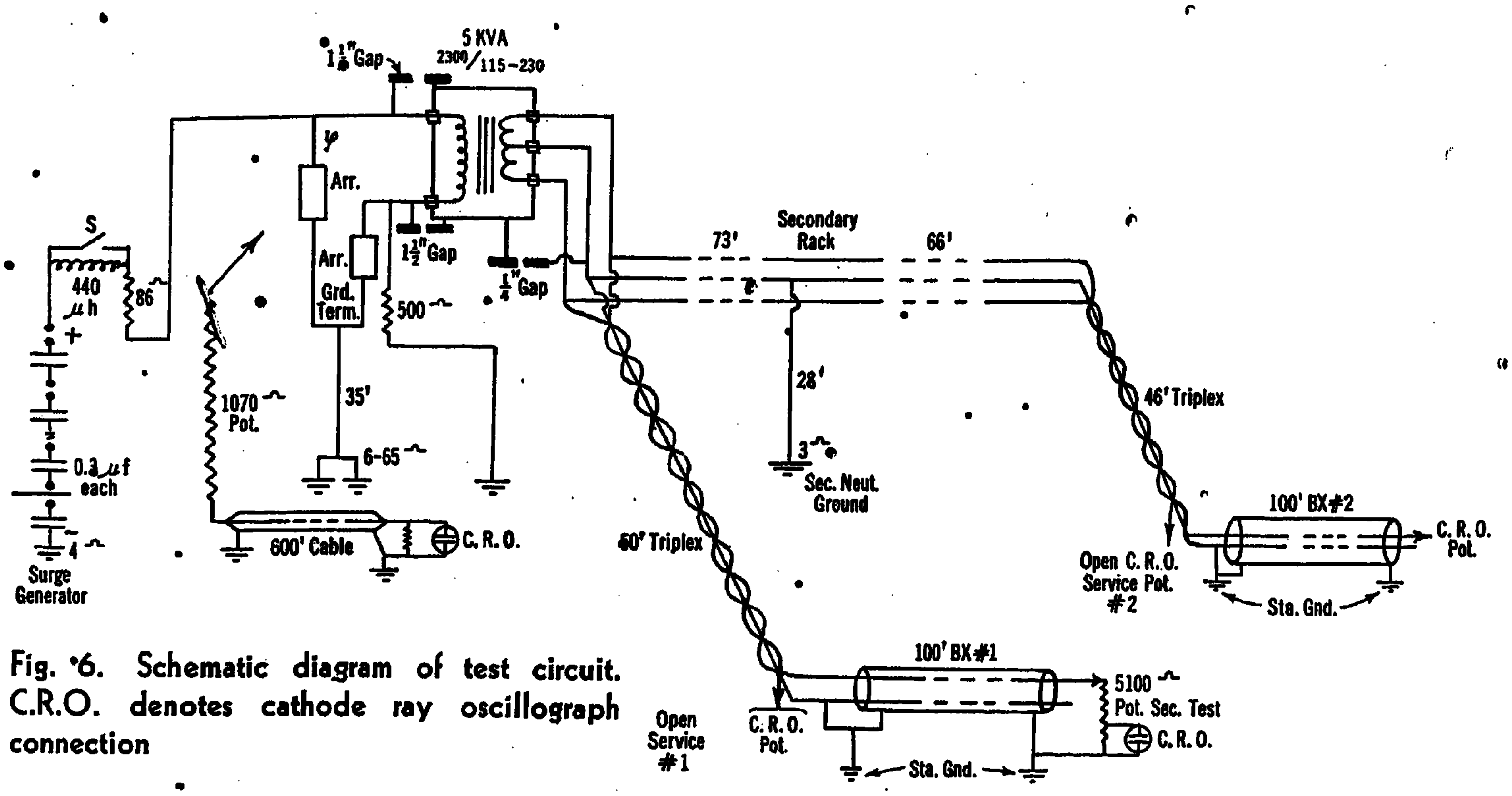

Fig. 6. Schematic diagram of test circuit. C.R.O. denotes cathode ray oscillograph connection

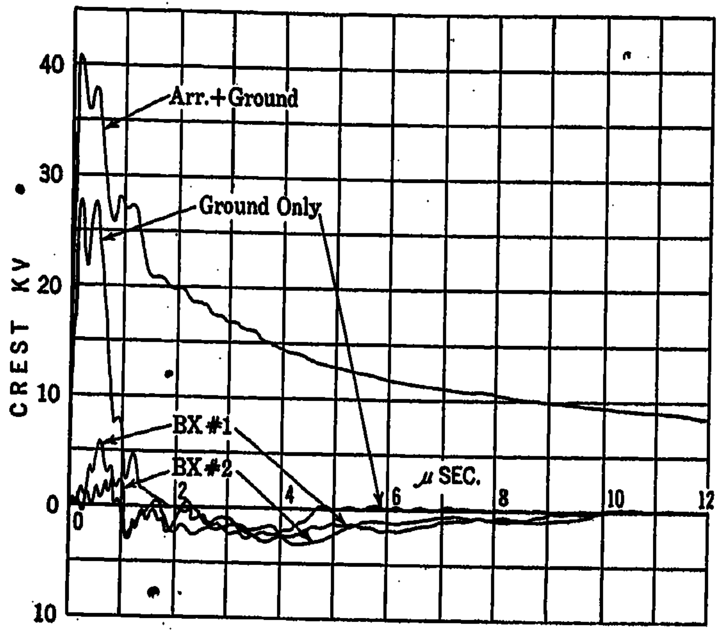

Fig. 7. Voltages measured in circuit of Fig. 6 with steep front surge of reduced magnitude

The gaps may have flashed accidentally during the oscillographic measurement of the voltage across the arrester lead plus ground, since the lack of sustained voltage seems incompatible with the given values of current and ground resistance, and also because the difference between the arrester-plus-ground and the arrester-lead-plus-ground voltages is greater than the arrester voltage, 15 kv. This curve is almost identical with the corresponding curve in Fig. 9

To secure consistent flashovers, gaps were placed around the primary and secondary bushings as shown in Fig. 21. A 500-ohm resistor was connected between the primary neutral and ground to simulate the effect of an uncharged conductor.

Arresters used in these tests were 3-kv autovalve arresters of the disk and mica spacer type. This type of arrester was selected rather than the porous block type because many of them are in service and because the tests were laid out to duplicate service conditions as closely as possible. Upon test, this type of arrester was found to have a maximum crest voltage of 15 kv across its terminals during a surge discharge of 800 amp.

Most of the oscillograms have been replotted to the same scale to show more readily the relative voltage-time values; a few of these are shown in Figs. 7 to 12, inclusive. Crest voltages measured at certain points for the various circuit connections and for each of the 2 types of impulse wave used are given in Table I.

Voltages at the transformer were measured by means of a cathode ray oscillograph connected to a 1,070-ohm resistance potentiometer through a delay cable. Voltages at the secondary service terminals were measured by a 5,100-ohm resistance potentiometer. These potentiometers of course have some effect on the surge voltages.

## Effect of the Ground Lead on Protection

To show the effect of the inductance of the arrester ground lead on the voltage appearing across the primary bushing, 2 rates of current rise were selected. The "slow" rate of current rise was produced by introducing the 400-microhenry inductance into the circuit of the surge generator (Fig. 6). The steep front surge rose to a maximum of 1,200 amp in 2 microseconds, while the slow front surge rose to 900 amp in 9 microseconds. Successive test surges were found to be practically identical.

With the surge generator set to give a current wave of fast front and a crest of slightly less than 1,200 amp in order to prevent flashover of the transformer gaps, the oscillograms shown in Fig. 7 were taken. In Fig. 8 are plotted oscillograms obtained using the slow front surge with no gap flashovers and with standard connections. Crest voltages for these tests are listed in Table I. These tests indicate that after an initial disturbance determined by the surge impedance of the ground lead, the voltage across the ground lead is determined by the lead inductance and the rate of change of current. The initial disturbance is due in part to the type of surge circuit used.

At the 1,200-amp surge generator setting the transformer gaps flashed over at 50 kv from line to ground; in Fig. 9 are plotted voltage oscillograms so obtained. As before, the crest voltages are listed in Table I. The voltage across open service No. 2 was 33 kv compared to 24 kv across BX No. 2, showing the attenuating effect of the BX cable on the surge.

### Tests With Arrester Ground and Secondary Neutral Interconnected

In Fig. 10 are plotted oscillograms taken when the arrester ground terminal and secondary neutral were interconnected. No gap flashovers took place. As may be seen, the difference in potential between the phase lead and the secondary neutral does not exceed 15 kv, the voltage permitted by the arrester alone. A comparison of columns 3 and 4 of Table I indicates that the crest secondary voltages are about the same with the interconnection as they are during a flashover of the transformer gaps without the interconnection.

The extreme case of high arrester ground resistance is that of no ground at all. Obviously with no ground the arrester could not discharge and any surge above 50-kv crest would flash over the transformer gaps. Under such conditions, protection for the transformer can be obtained by connecting the arrester ground terminal to the secondary neu-

Surge voltages measured in the circuit of Fig. 6.

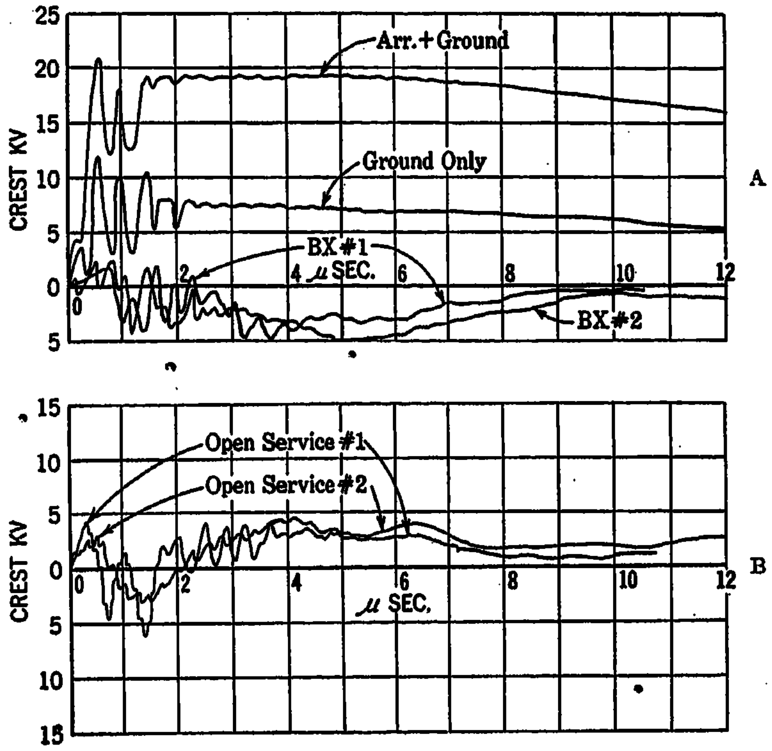

Fig. 8 A and B. (Left) Slow front surge with no transformer gap flashovers

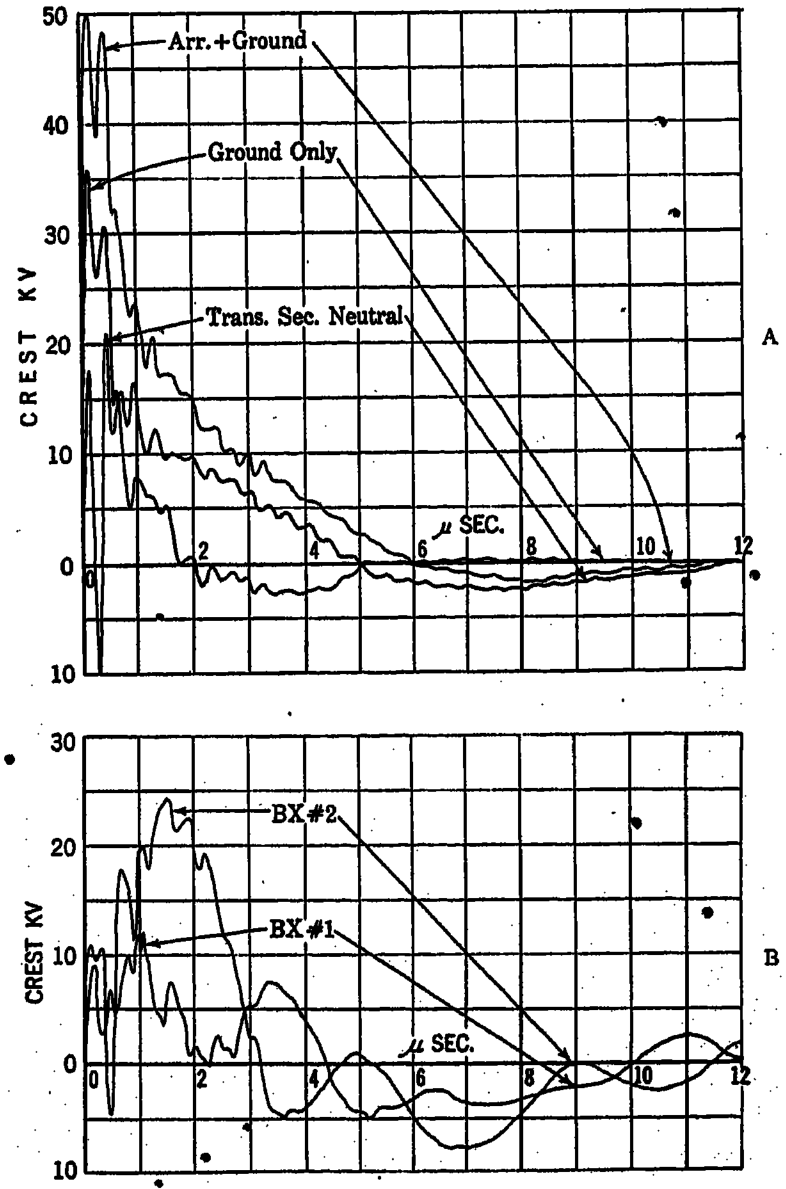

Fig. 9 A and B. (Left) Steep front surge with transformer gaps flashing over

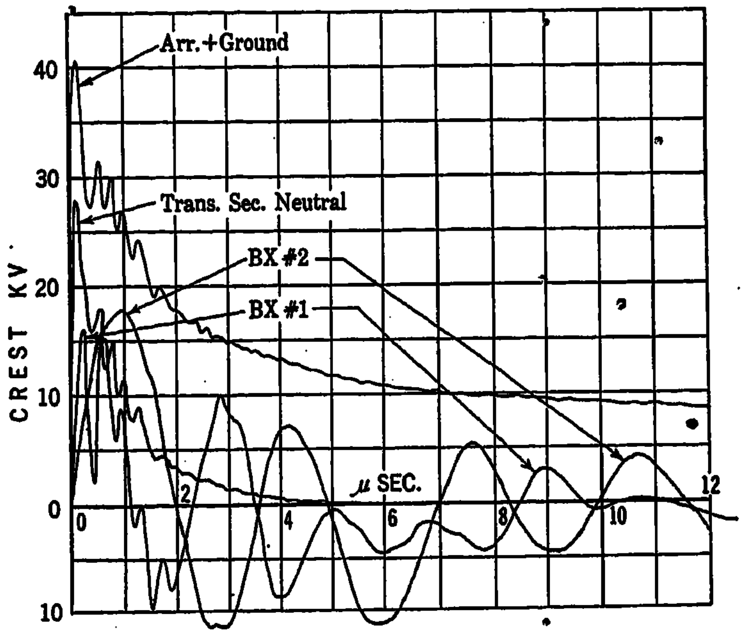

Fig. 10. (Right) Steep front surge with arrester ground and secondary neutral interconnected; no transformer gap flashovers

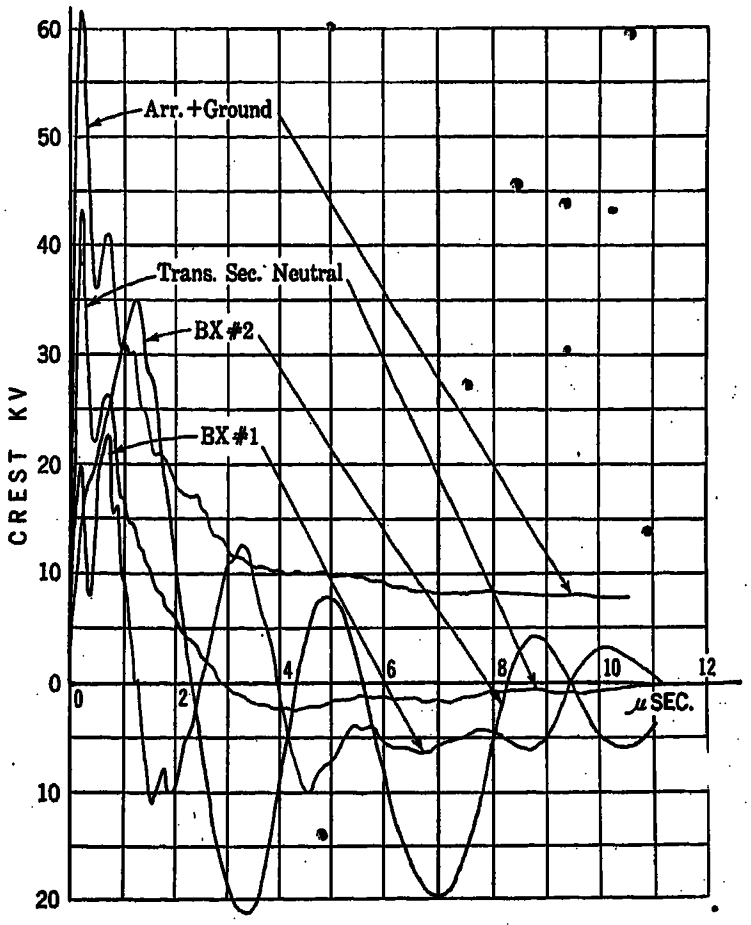

Fig. 11. (Right) Steep front surge with primary arresters not grounded at the transformer but connected to secondary neutral only; no transformer gap flashovers

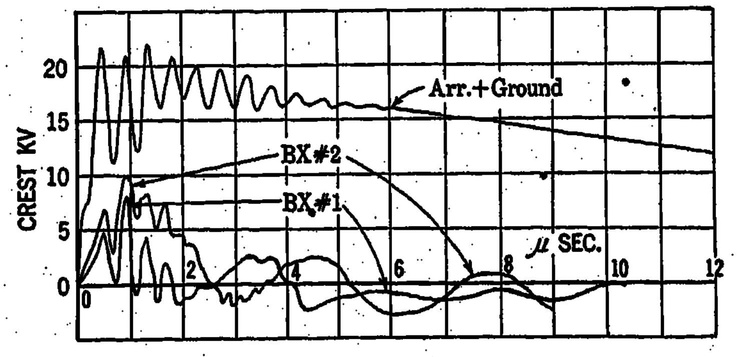

Fig. 12. (Right) Slow front surge with primary arresters not grounded at the transformer but connected to secondary neutral; no transformer gap flashovers

## Table I—Crest Voltage Measurements

| | Steep Front Surge | | | | Slow Front Surge | | |
|---|---|---|---|---|---|---|---|
| Column 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | Standard Connection | | | | | | |
| Point of Voltage Measurement* | Gaps Not Flashing | Gaps Flashing | Arr. Ground and Secondary Neutral Interconnected | Arrester Ground to Secondary Neutral Only | Standard Connection Gaps Not Flashing | Arrester Ground to Secondary Neutral Only | Arrester Grounded as in Fig. 5 |
| Arrester plus ground | +41 kv | +50 kv | +41 kv | +62 kv | +21 kv | +21 kv | +21 kv. |
| Arrester ground lead | +28 | +36 | | | +12 | | |
| Trans. sec. neutral | | +20 | +28 | +43 | | | |
| Open Service No. 1 | + 3 | +25 | +20 | +35 | + 3 | | |
| BX No. 1 | − 3 | +12 | +16 | +23 | − 4 | + 8 | +14 |
| Open Service No. 2 | + 3 | +33 | +34 | +56 | + 4 | | |
| BX No. 2 | − 3 | +24 | +18 | +35 | − 5 | +10 | +19 |
| Oscillograms plotted | Fig. 7 | Fig. 9 | Fig. 10 | Fig. 11 | Fig. 8 | Fig. 12 | — |

* All voltage measurements were made by resistance potentiometers and cathode ray oscillographs.

tral. To investigate this the circuit of Fig. 6 was modified by connecting the ground terminals of the primary arresters to the secondary neutral only. Under such conditions the full surge current flows to ground through the transformer secondary neutral wire. Figs. 11 and 12, respectively, show the voltages measured with steep front and slow front surges. In neither case did the transformer gaps flash over, as the voltage across the transformer bushings was limited by the arrester to about 15 kv. The maximum voltage to ground with the fast surge was 60 kv, which was considerably above the gap flashover voltage.

A test was made to investigate the effects of the indirect interconnection of the secondary neutral and arrester ground, using the circuit shown in Fig. 5 except that the separate arrester ground was omitted so that the only path for the arrester surge current was through the secondary arresters, secondary windings, and secondary neutral to ground. Crest voltages for this test are shown in Table I column 8. A comparison of columns 7 and 8 of Table I shows that the leakage reactance between the 2 secondary windings of this transformer evidently was high enough to increase the voltage appearing across the service wires. This same circuit was tested with the steep-front surge. The voltage was sufficiently great to cause a flashover in the BX cable, so no measurement was made; however, no flashover occurred on the transformer gaps.

### Surge Voltages Appearing on the Secondary

A surge voltage impressed across the primary of a distribution transformer will induce a voltage across the secondary; this voltage has a duration about the same as that of the primary voltage. A rapidly changing surge current passing to ground over the secondary neutral produces an oscillatory voltage between the outside wires and ground at the service terminals, the maximum value of which is about the same as that of the transformer neutral to ground at the transformer. However, the voltage on the BX cable (Fig. 6) is lower than that on the corresponding open service; and the voltage on the more distant service, No. 2, is greater than that on service No. 1.

Voltages appearing at the services when the arrester ground and secondary neutral are interconnected are about the same as those appearing when a steep-front surge causes the transformer gaps to flash over due to the inductive drop in the arrester ground lead.

Secondary voltages with the arrester ground and secondary neutral interconnected, though of short duration, appear to be of rather high magnitude. While the secondary voltages with this circuit may be compared with corresponding voltages on the other circuits tested, it should be noted that the length of racked secondary was short as compared with lengths usually found in practise, and that voltages on an actual distribution system probably will be lower. Voltages of the relative magnitudes tabulated in column 3 of Table I appear now without serious effect for transformer flashovers where the ground resistance is low.

### Conclusions

Tests show that when a transformer is subjected to a lightning surge the case will assume a potential of about 10 per cent of that appearing between the primary leads and secondary neutral. Neglecting the potential of the case the voltage across the transformer bushings is the sum of the voltages across the arrester, the arrester ground lead, and the arrester ground resistance. With a surge of steep front the inductive voltage across the ground lead alone may exceed the arrester voltage. Remedial steps which can be taken are limited to a reduction of the arrester ground resistance and of the inductive drop across the ground lead. Practical application of these measures is limited by field conditions.

Improved protection of a distribution transformer may be secured by any one of several methods of connecting the arrester ground lead to the secondary circuit. The following methods will limit the surge voltage across the bushings to approximately the characteristic crest voltage of the primary arrester, but will differ in resulting secondary voltages:

1. Direct connection of a low resistance primary arrester ground to a grounded secondary neutral produces no higher voltages at the customer's service than are experienced when flashover occurs with present protection schemes.

2. Direct connection of a high resistance primary arrester ground to a grounded secondary neutral results in higher surge voltages appearing on the customer's leads than when the ground resistance is low.

3. Connecting the primary arrester ground to the secondary neutral

through a low voltage arrester gives substantially the same results as the direct connection.

4. Connecting the primary arrester ground to the secondary outside wires through 2 low voltage arresters results in increased surge voltage at the service.

# II—Tests on a Typical Urban Circuit

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C. S. SPRAGUE ASSOCIATE A.I.E.E.

Both of Purdue University, Lafayette, Ind.

UNDER a cooperative arrangement with the Utilities Research Commission of Chicago, the engineering experiment station at Purdue University has been conducting an investigation of surge protection for distribution circuits. Many of the tests have involved the interconnection of the primary lightning arrester ground and the grounded neutral of the secondary main; it is this phase of the work which will be treated in this article.

After some preliminary work, a 5-span distribution line was constructed, over which was supported an insulated artificial cloud for the purpose of inducing surge potentials in the distribution system. The distribution line was of the double-crossarm wood-pole type with 4 4,000-volt primaries on the upper arm and 6 secondaries on the lower arm, the latter comprising a 3-phase, 230-volt power circuit and a single-phase 115/230-volt lighting circuit (see Fig. 15). The line was built in accordance with the standard construction practise of the Commonwealth Edison Company of Chicago. A bank of 3 distribution transformers and a customer's service were included in the distribution system but were not connected to any 60-cycle supply. Circuit grounds were made on the customer's service and on the distribution system as in standard practise. (See Fig. 13 for circuit diagram.)

## POTENTIALS INDUCED ON LINE WIRES

The cloud normally was held at ground potential by means of a high resistance leak. At definite intervals a surge generator was made to discharge into the cloud, thereby causing a sudden change in cloud potential with consequent induced voltages in the distribution system. These induced voltages were measured by a sphere gap at the transformers and at the customer's service entrance.

A series of tests was made in which the induced voltages to ground were measured as the distribution system was built up step-by-step, that is, by starting with the wires only and adding the circuit grounds, arresters, transformer windings, etc., until the system was complete. In Fig. 14 is shown graphically the change in the magnitude of induced voltages during this procedure, and also the system voltages with and without the interconnection of the secondary neutral to the primary arrester ground.

In general, Fig. 14 is self-explanatory, but it is desired to call attention to some of the more interesting changes in the induced voltages and their causes. As noted in the legend, the first vertical line of each group represents the induced voltages on that particular wire with no grounds or connected apparatus. Potentials induced on the primary wires (between wires 1 and 4 and ground) were approximately 90 kv; on the secondary wires (between wires 5, 8, 9, and ground) approximately 75 kv. (See Fig. 15 for positions of wires on crossarms.) In test 2 of each group, wire No. 9 (secondary neutral) was connected to a driven pipe ground of approximately 15 ohms resistance, one span distant from the transformer bank. Aside from the reduction in voltage on wire No. 9, itself, it is interesting to note the reduction on wires 4 and 8, adjacent to wire No. 9.

Test 3 of each group indicates the voltages with the further addition of primary phase and neutral arresters. As would be expected, there was a marked decrease in the potentials of all primary wires. There occurred also a decided reduction in the potentials of the secondary wires (wires 5, 8, 9) due to the shielding effect of the primary wires after the arresters had broken down. This is particularly significant and important for it indicates that in the field a well protected primary system provides considerable protection for secondaries located below the primaries.

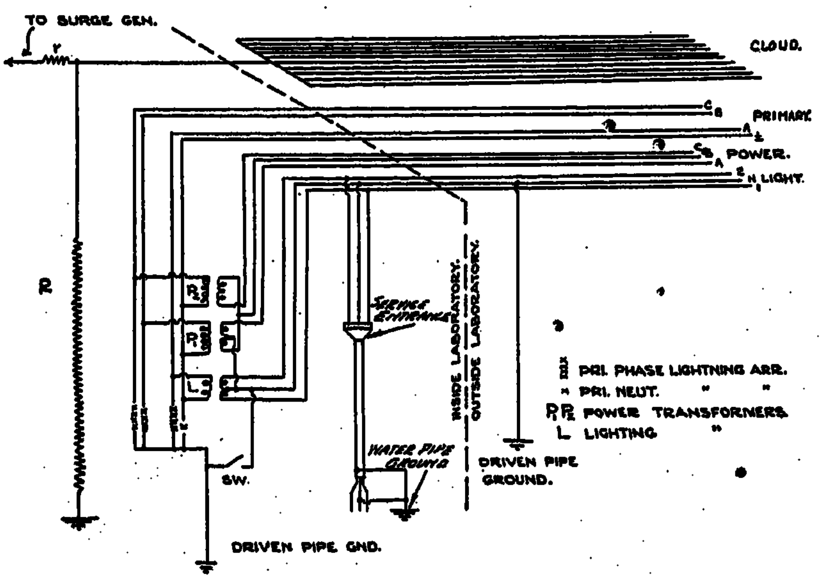

Fig. 13. Circuit diagram of experimental distribution system and artificial cloud

In Test 4, connecting the transformer primary windings caused but slight reduction in induced potentials, showing that the primary winding presents a relatively high impedance to the surge. With transformers, house-wiring circuit, and all grounds connected to the circuit, as in Fig. 13, voltages to

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Based upon "Interconnection of Primary Lightning Arrester Ground and the Grounded Neutral of the Secondary Main" (No. 32-16) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25-29, 1932. Revised especially for ELECTRICAL ENGINEERING and brought up to date.

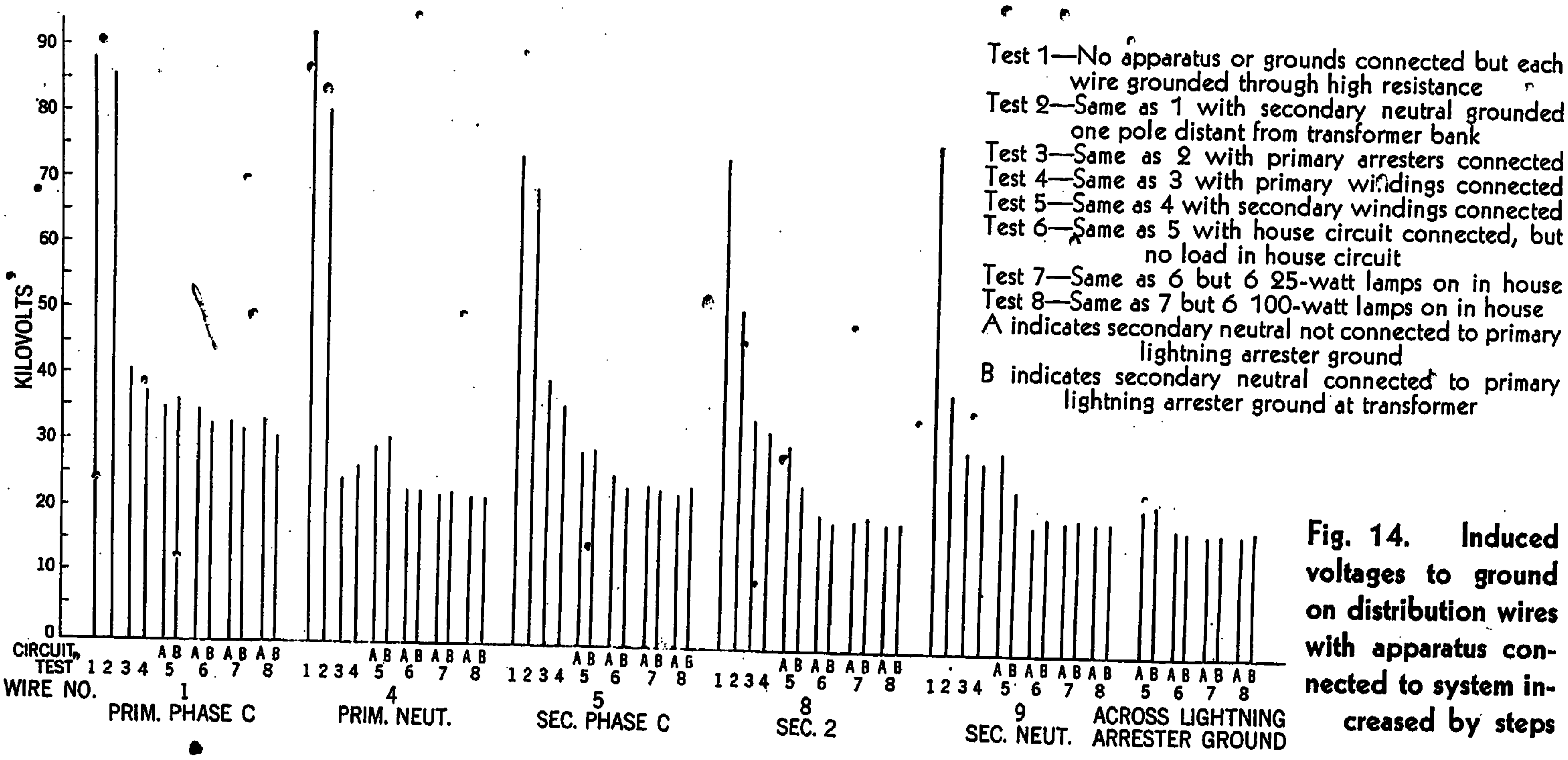


**Fig. 14. Induced voltages to ground on distribution wires with apparatus connected to system increased by steps**

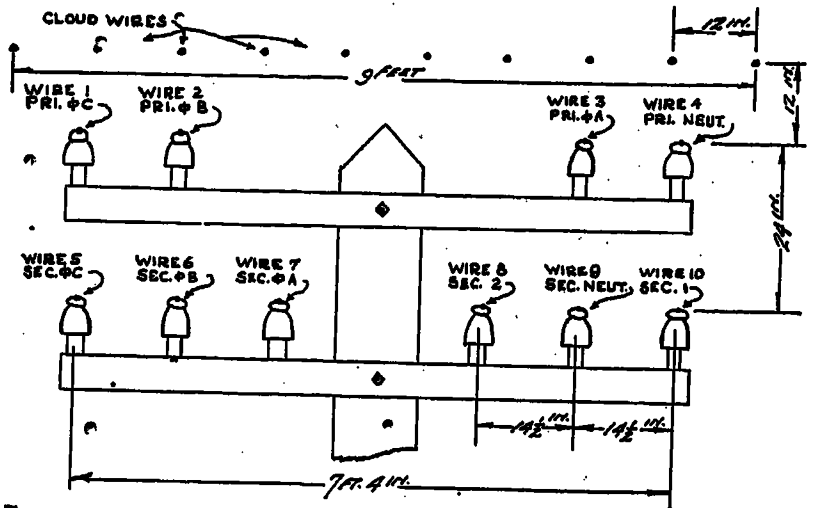


**Fig. 15. Arrangement of artificial cloud and line wires**

ground on the power and lighting secondaries and on the primary neutral were of the order of 20 to 25 kv while those between the primary phase wires and ground were of the order of 30 to 35 kv.

## POTENTIALS INDUCED IN TRANSFORMER WINDINGS

With regard to voltages across transformer windings it was determined that for a single-phase lighting transformer with its secondary neutral grounded, the voltage across the secondary winding was approximately 5 to 15 per cent of that across the primary winding. With 3-phase 230-volt Δ-connected power secondary windings having the midpoint of one winding grounded to the lighting secondary neutral, it was determined that the voltages across the secondary coils were approximately 20 to 80 per cent of those across the primary windings. In both cases the induced potentials overstress the secondary insulation without exceeding the safe limit on the primary insulation. A solution of this difficulty is of course to increase the insulation of the secondary winding. In so doing, however, capacitances between primary, secondary, and core will be changed; therefore consideration should be given to the redistribution of potentials resulting therefrom. These are relatively inexpensive additions to the design and construction of the transformer.

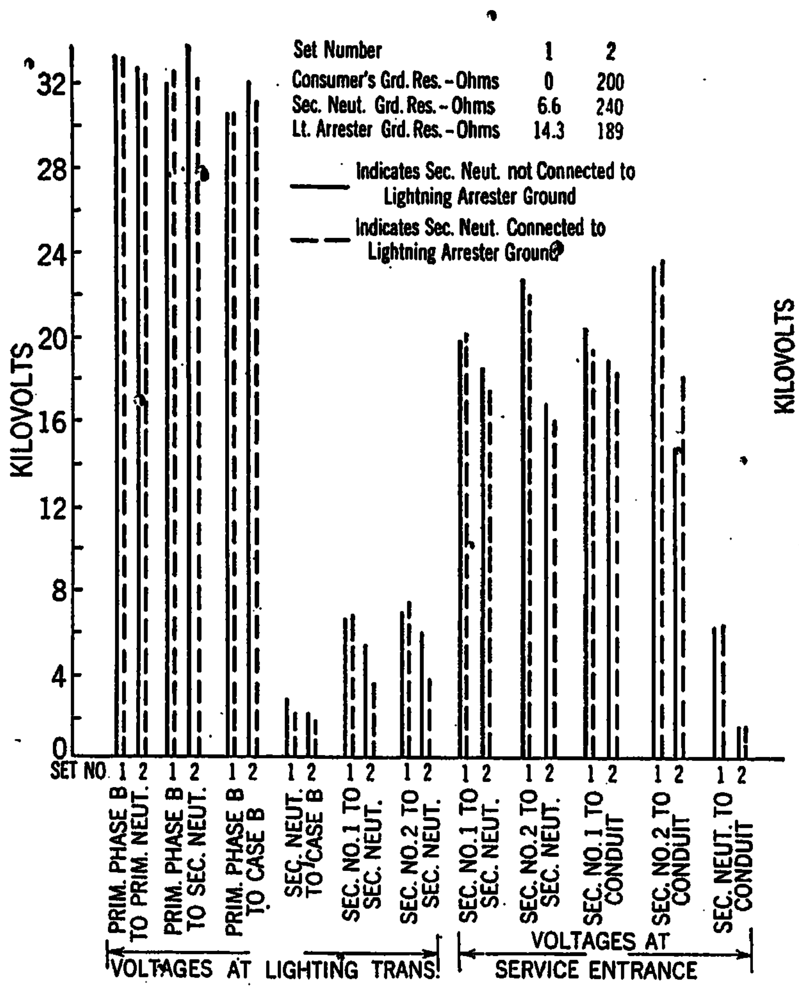
In the preceding group of tests interconnecting the secondary neutral and the lightning arrester ground caused, in general, approximately 5 per cent decrease in magnitude of the induced voltages to ground. The tests indicated, however, that the effect of this connection depends to a large extent upon such factors as the steepness of wave front of the surge, and time lag of the primary arresters; hence, under the test conditions of induced potentials and arrester currents of small magnitudes, it cannot be said that this connection *always* is beneficial.

## TESTS WITH DIFFERENT GROUND RESISTANCES

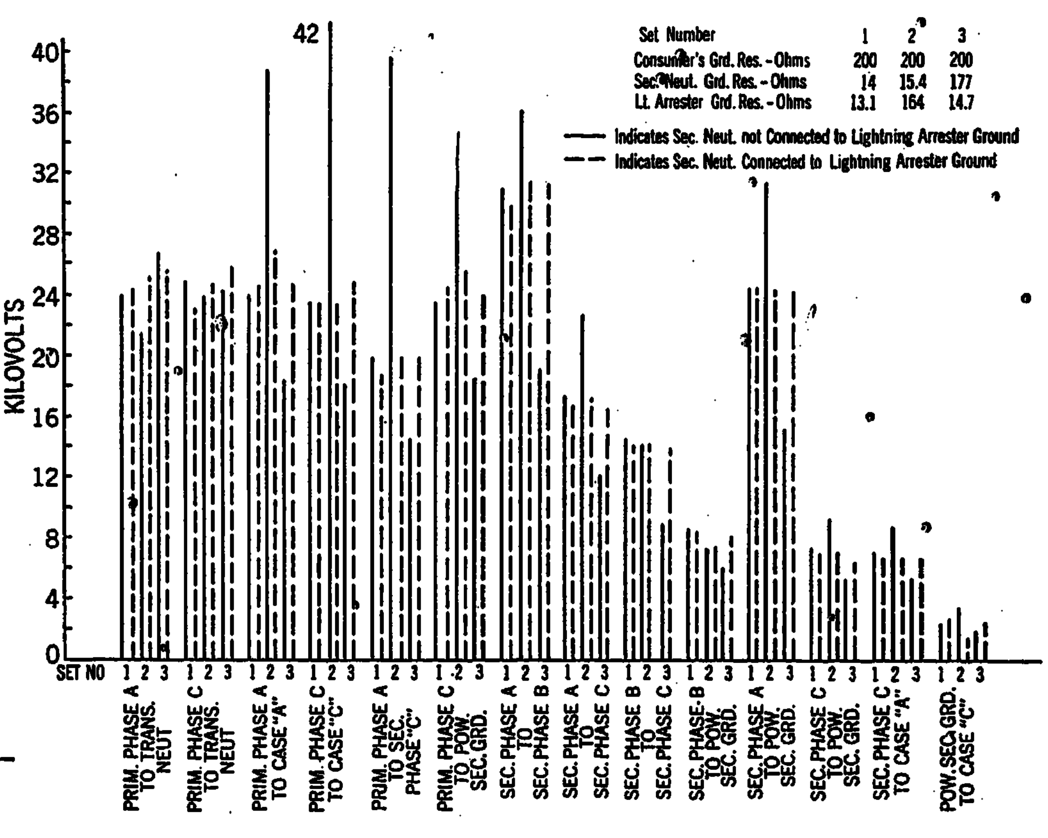
Induced voltages measured at the transformers and at the service entrance under various conditions of ground resistance are shown graphically in Figs. 16 and 17. Tests were made both with and without interconnection of the secondary neutral to the primary lightning arrester ground. In several instances the interconnection caused a marked decrease in the voltage between primary phase wire and secondary ground.

Field investigations have demonstrated that many transformer failures and blown fuses have been caused by flashover from a primary phase lead to the transformer case and thence to the secondary neutral. In fact, operating companies have reported that in about $^3/_4$ of the transformer failures on distribution systems due to lightning, the damage involved both the primary and secondary windings.

Measurements of induced voltages between primary phase lead and secondary neutral have shown that the interconnection of the secondary neutral with the lightning arrester ground in general is beneficial to the transformer. In particular, with a low resistance secondary neutral ground and a high resistance lightning arrester ground, the interconnection reduced this voltage by 30 to 50 per cent. (See Fig. 17, set 2.) With no interconnection and with a high resistance secondary neutral ground and low resistance lightning arrester ground, the voltage between primary phase lead and secondary winding



Secondary neutral ground one span from transformer pole



Secondary neutral ground at transformer pole

**Fig. 16 (left) and 17 (right). Effect of interconnection upon the potentials at the transformers and at the service entrance with various ground resistances**

was somewhat reduced at the expense of an increased voltage across the high resistance secondary neutral ground. By making the interconnection and thereby connecting the low resistance lightning arrester ground in parallel with the high resistance secondary ground, there was a redistribution of voltage so that the potential between primary phase lead and secondary neutral was approximately the same as when using the interconnection and with low secondary neutral ground resistance and high lightning arrester ground resistance. (See Fig. 17, set 3.)

### Potentials at Service

As indicated by Fig. 18, the tests showed that due to making the interconnection there was a 10 per cent reduction in the potentials at the service entrance. There is indicated also a marked reduction in the voltages at the service entrance when the customer's lamps were turned on. This seems to be an argument in favor of turning on the lamps during a thunderstorm.

During the latter part of the work the transformers were mounted on one of the poles and a testing shelter was constructed on poles immediately adjacent to the transformer pole. The induced potentials were slightly higher, but otherwise in good general agreement with those obtained when the transformers were on the laboratory floor. The majority of the tests covered here have been made with the transformers on the poles.

Subsequent to the preparation of the paper presented at the winter convention in New York, tests have been made with the surge generator discharging directly from the cloud into a primary phase wire, giving arrester currents up to 2,000 amp. Under these conditions, the beneficial effect of the interconnection was much more pronounced. Whereas with secondary neutral ground resistances of from 10 to 15 ohms and arrester ground resistances of from 100 to 200 ohms, the transformer bushings repeatedly flashed over, it was found that the interconnection in all cases prevented flashover and reduced the potentials across the transformer to approximately 35 kv.

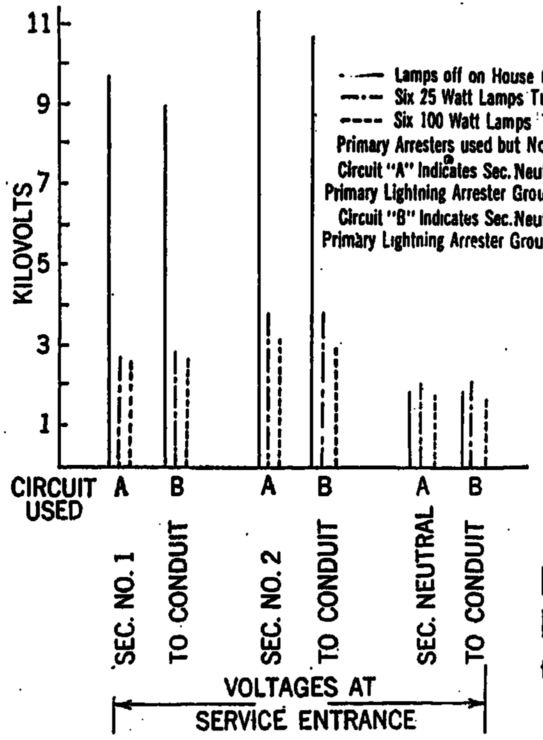


**Fig. 18. Effect of lamp load upon surge potentials at service entrance**

Laboratory surge tests were made on several of the newer surge-proof distribution transformers and also on some rather old and dirt-covered transformers which had seen considerable service. With a lightning arrester operating normally and connected between primary phase and secondary neutral (equivalent to the interconnection) none of the transformers showed any signs of failure.

While in no way depreciating the advantages of the present surge-proof type, this would indicate that increased service and reliability may be obtained from some of the old style transformers if the interconnection is adopted.

Surge tests on the primary bushings of some surge-proof type transformers indicate that well over 100 kv is required to flash over the bushing, due primarily to several layers of cambric tape on the phase lead. In case of possible arrester failure it is evident that the winding insulation may be subjected to abnormally high stress without relief by bushing flashover.

## CONCLUSIONS

From the results obtained in this investigation, the following conclusions seem justified:

1. The value of an experimental wood pole distribution line with an insulated artificial cloud charged by a surge generator was established definitely for lightning protective investigations involving induced as well as direct stroke potentials.
2. The tests demonstrated the practicability and economy of studying, by means of such equipment, the operation of various transformer, lightning arrester, and ground connections, when exposed to surges approximating those of lightning.
3. Efficient primary protection on an overhead distribution line affords considerable protection to secondaries located below the primaries.
4. A well grounded secondary neutral wire reduces potentials on adjacent wires.
5. In existing transformer design the insulation of the secondary winding may be overstressed by steep wave front surges without excessive stress on the primary insulation; such stresses may be relieved by improvements in secondary insulation.
6. Low ground resistances, although desirable in other respects, do not necessarily reduce the initial potentials which may be induced on the system.
7. A non-inductive load in the consumer's premises reduces the potentials 60 to 70 per cent at the service entrance.
8. Interconnecting the primary lightning arrester ground to the grounded neutral of the secondary main greatly reduces the voltages at the transformer and imposes no extra hazard upon the consumer's wiring. Specific cases of this conclusion are covered in the following 4 paragraphs.
9. With the lightning arrester ground resistance and secondary neutral ground resistance below 20 ohms, the interconnection has but little effect upon the magnitudes of induced potentials at the transformer.
10. With an arrester ground of from 100 to 200 ohms and a secondary neutral ground of less than 20 ohms, the interconnection reduces by from 30 to 50 per cent potentials across the transformer terminals.
11. With a lightning arrester ground of less than 20 ohms, and a secondary neutral ground of from 100 to 200 ohms (an unusual combination), the potentials across the transformer terminals were increased about 25 per cent by making the interconnection.
12. With secondary neutral and primary arrester ground resistances both ranging from 100 to 200 ohms, the interconnection had practically no effect upon the magnitudes of the voltages at the transformer.
13. Using "direct strokes" from the surge generator, the interconnection is of great benefit with high arrester ground resistances. With any combination of secondary-neutral and arrester ground resistances, the interconnection limits the transformer stress to the value determined by the arrester voltage, and should reduce materially the lightning failures on non-surge-proof types of transformers.
14. With usual city conditions, consisting of a multiplicity of low resistance grounds on the secondary neutral, and the further possibility in some instances of a lightning arrester ground of high resistance, it has been demonstrated herein that potentials at the transformer may be reduced greatly by the interconnection of the primary lightning arrester ground and the grounded neutral of the secondary main.

# III—Tests on a Typical Rural Circuit

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THERE HAS BEEN a growing conviction on the part of those closely associated with the problem of protection that in practise the present method of lightning arrester application on distribution systems involves too many uncontrollable factors. Connecting the primary arrester ground to the grounded secondary neutral appears to eliminate many of the uncontrollable factors. With such a connection the voltage between transformer windings under impulse conditions will not exceed the potential allowed by the arrester; this potential is so low that bushing flashovers or transformer failures should be practically eliminated. In proposing this the question naturally arises: Will such a connection introduce any additional hazard on the customer's premises and will it offer the advantage from the protection standpoint that apparently it should? Experience in those cases where this interconnection has been tried does not indicate any increased hazard, and the protection record seems to be far above that of the present connection.

In order that experimental data might be obtained under controlled test conditions, the General Electric Company conducted a field investigation in cooperation with the Associated Gas and Electric Company. The tests were made on a single-phase 4,600-volt rural line of the New York State Electric and Gas Company, built to serve the village of Willseyville, N. Y., and the surrounding community. The line had just been constructed at the time the tests were made and for most of the power tests was energized at 2,300 volts. A portable million volt impulse generator and a cathode ray oscillograph were used in the tests. A positive impulse voltage of 350 kv applied resulted in a 6/14 microsec wave with a crest of 123 kv at the test transformer location 4.45 miles away. To prevent flashover, it was necessary to increase materially the insulation at most of the guyed poles.

A 10-kva 2,300–115/230-volt transformer was mounted about 30 ft above ground on the pole at which the primary conductors terminated. The 3 secondary conductors $X_1$, $X_{23}$, and $X_4$ extended from this pole into the village of Willseyville, having a total circuit length of 3,273 ft located on 4 streets. (See Fig. 19.) A building which will be designated

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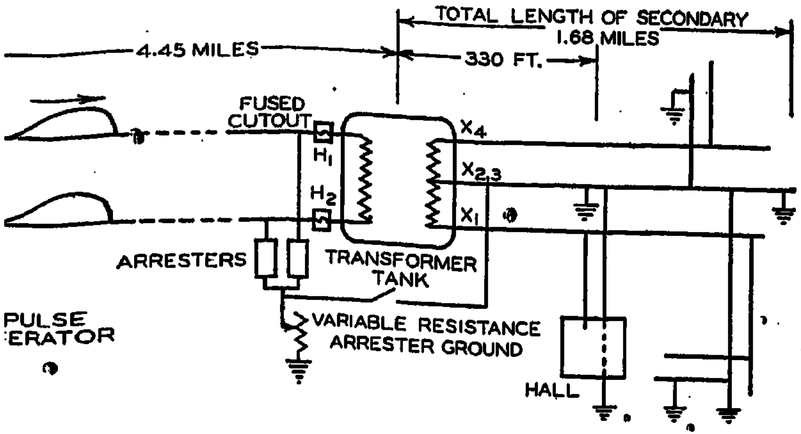
Based upon "Lightning Protection for Distribution Transformers" (No. 32-17) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932. Revised especially for ELECTRICAL ENGINEERING and brought up to date.



. 19. Circuit connections for protection tests on transformers

"hall" was connected between $X_1$ and $X_{23}$
oint about 400 ft from the transformer pole.
uilding was the only one connected to the
ary circuits during the tests. In addition to
-ohm ground at the hall the secondary neutral
ounded at 5 points, the nearest being about
from the transformer pole. The combined
nce of all secondary grounds was 25 ohms.
hall was wired with metallic armored cable
the measured capacitance between 1 wire
round was 0.04 µf. The hall was provided
circuits and 26 outlets, the ground being
to the casing of a driven well.
athode ray oscillograms to be shown registered
es to ground. Voltages between windings are
ed by subtraction, but were checked by direct
rements with sphere gaps. Resistance and
tance dividers were used to reduce the po-
s to proper values for the oscillograph deflect-
ates. Most of the tests were made with 3-
llet arresters which, according to laboratory
have a breakdown potential of about 17 kv
n *IR* drop of 6 to 7 kv. Some of the tests
nade with pellet arresters having higher rat-

### SE APPLIED TO THE PRIMARY

y results with impulses on both primary con-
s will be given as this is the most representa-
ondition of service and the conclusions drawn
equally well whether the impulse is on 1 con-
or both. Although nearly 1,000 oscillo-
were taken, in the limited space available
few of the data can be shown.

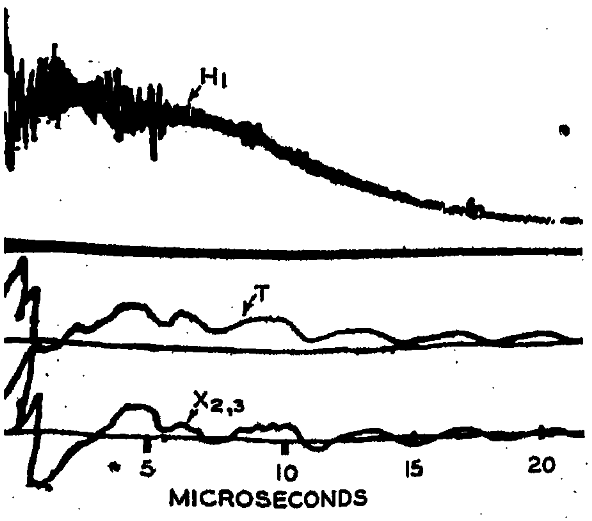
Oscillograms reproduced in Fig. 20 show the potential with respect to ground of the primary $H_1$, tank $T$, and secondary neutral $X_{23}$ with the 3-kv primary arresters connected to a 10-ohm ground in the usual manner. The secondary neutral potential remains close to ground potential while the tank takes an intermediate potential, but close to the secondary. As a result, most of the potential allowed by the primary arrester and its ground is impressed from the primary to tank and secondary.

Increasing the arrester ground resistance to 60 ohms increases the primary potential to tank and secondary and also increases the tank potential, as shown in Fig. 21. It is clear that further increase in arrester ground resistance is likely to result in either flashover of the primary bushings or a winding failure. Flashover of both primary bushings, or cascade flashover of a primary and secondary bushing, if the primary is grounded, is likely to result in blown fuses.

Interconnecting the arrester ground and secondary neutral greatly reduces the potentials between windings and from winding to tank as shown in Fig. 22. With this connection the oscillograms show that the tank and secondary have practically the same potential, while the primary to secondary potential is only the arrester potential, although the arrester ground resistance was 60 ohms.

In Fig. 23 the oscillograms of Figs. 21 and 22 are subtracted to show the great reduction in potential between primary and secondary when the arrester and secondary neutral were interconnected. Additional tests show that there is little difference of potential between the different windings even with the arrester ground disconnected. (Fig. 24.) Thus, regardless of the arrester ground resistance the transformer is well protected and fuse blowing is reduced to a minimum by eliminating bushing arcover.

Tests made using 6-kv pellet arresters with and without the tank connected to the arrester ground, which had a resistance of 10 ohms, are shown in Fig. 25. The oscillograms are replotted as they were taken with different time scales. The impulse was applied to both primary conductors, the secondary conductors still being connected to the secondary distribution system. The results show that the connection of the tank to the arrester ground

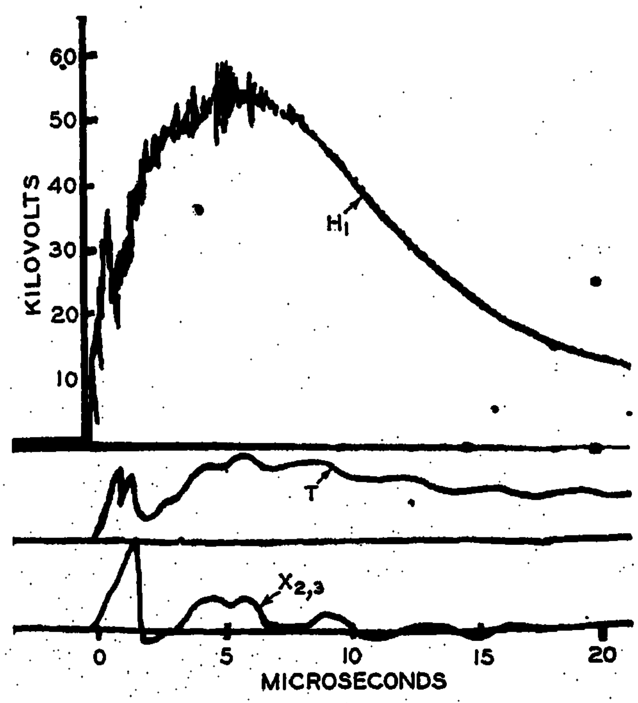


Potentials measured at the transformer when impulses were applied to the primary conductors. Primary lightning arresters grounded at the transformer pole in the usual manner

Fig. 20. (Left) Arrester ground resistance 10 ohms

Fig. 21. (Right) Arrester ground resistance 60 ohms

Oscillograms in each group have same calibration



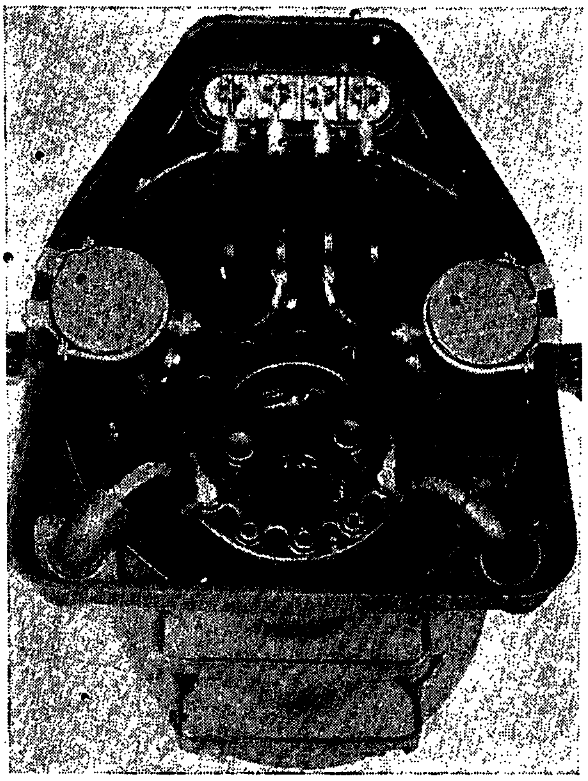


Fig. 28. Intershunt Thyrite lightning arresters mounted in a 25-kva distribution transformer for operation on a 2.4-kv isolated system

close to the transformer. Thus accidental connection between primary power supply and customer's premises should be practically eliminated.

5. Surge potentials at the transformer with the arrester ground interconnected to the secondary neutral is independent of the arrester ground resistance so that the transformer is protected whether the arrester ground resistance is high or low.

6. With the arrester ground interconnected to the secondary neutral, nothing is to be gained by connecting the transformer tank to the secondary neutral, since with the tank "floating," the potentials to tank are much less than the strength of insulation involved and the hazard to linemen is decreased.

7. Interconnection of primary arrester ground and secondary neutral allows impulse current to flow into the secondary network, the amount depending on the arrester ground at the transformer. The tests showed that even a 10-ohm ground did not prevent flashing some of the small gaps in the secondary house wiring; lightning discharges originating on the secondary do the same thing and interconnection increases the number of such discharges by the amount of exposure added. If a good arrester ground is used the severity of discharge in the secondary circuits will be reduced greatly. It is not believed that the increase in the number of discharges represents any increased hazard where the secondary neutral is connected to water pipe grounds, as in cities, even if the arrester is not grounded at the transformer. In rural distribution interconnection may represent some increase in hazard if several different grounds exist within consumer's premises so as to allow potential differences between different grounded objects and the secondary circuits.

8. From the standpoint of hazard due to power voltage, the present situation is that, in many instances of fuse blowing that may or may not have resulted from a transformer failure, power voltages of considerable magnitude appear between the secondary ground and separate grounds on the customer's premises; these voltages will persist until the fuse blows which may require many cycles, depending on the magnitude of the fault current. With good grounds on the secondary this time will be short and the voltage low; with poor grounds the time is longer and the voltage higher.

9. With the interconnection, it is believed that contacts between primary and secondary caused by lightning largely will be avoided thus materially reducing any hazard that may have existed before where the secondary ground resistance was high. In such cases the arrester probably should be connected to a ground at the point of interconnection to the secondary neutral.

10. The tests indicate that the record of arrester protection to distribution transformers, including fuse blowing, can be improved greatly by the interconnection, providing proper precautions are taken where the secondary neutral ground is not a water pipe ground; arrester grounds are not necessary where the secondary ground resistance is low as with waterpipe grounds.

## Additional Notes on Interconnection

Since the paper upon which the foregoing article is based was written, tests have been completed by Duvoisin and Brownlee ("Impulse Characteristics of Fuse Links," *G. E. Rev.*, May 1932, p. 260) which indicate that valve type lightning arresters may be connected inside of fuses without having the arrester discharge current blow the fuses. These tests show that in order to blow a 1-amp low temperature General Electric fuse link a 1.5/40-microsec impulse must have a crest voltage of at least 123 kv; to blow a 5-amp fuse under the same conditions the crest potential of the traveling wave must be at least 625 kv. Considering the insulation of most distribution circuits it is doubtful if fuses of a capacity as large as 3 amperes would be blown by the discharge current through a valve type lightning arrester. The effect of the power follow current through such an arrester is quite negligible from the standpoint of blowing fuses during a lightning storm.

With interconnection of lightning arresters it is essential that some means be provided for clearing the circuit in the event that the arrester should fail. Connecting the arrester inside the fuses provides a satisfactory method for doing this, and not only isolates the arrester but also locates the trouble so that it may be cleared quickly. The impulse tests on fuses show that this protection can be secured satisfactorily without any sacrifice in service reliability if fuses of 3-amp rating or larger are used.

There has been some discussion concerning the use of interconnection on circuits operating nongrounded, on account of the potential that might appear between the consumer's wiring and a separate ground. Available information indicates that on a 4.6-kv system the potential across a ground resistance of 100 ohms connected between one line and ground would not exceed 100 volts, the system being 20 miles in extent. This assumes, of course, that the line conductors are free from grounds. It does not appear, therefore, that the failure of a lightning arrester would cause any serious voltages on the consumer's premises even with a ground resistance as high as 100 ohms.

Several of the larger operating companies now are trying interconnection on a scale sufficiently large that the results taken as a whole should be quite conclusive. Some of these companies who have felt doubtful of the interconnection in relation to the various codes have obtained the approval of the engineers of the Public Service Commissions of their particular states.

### INTERSHUNT THYRITE LIGHTNING ARRESTER

If interconnection be employed it is convenient to mount the arrester inside the transformer tank so as to avoid external connections, thus decreasing the cost of installed protection and the amount of apparatus separately mounted on the pole. For this purpose a special Thyrite arrester has been developed consisting of an assembly of gaps and Thyrite within a sealed porcelain container and hung from the inside of the transformer tank. A transformer so protected is shown in Fig. 28. Such a location of the arrester insures the minimum length of leads and makes it possible for the arrester, which is connected between the primary conductors and secondary neutral, to function most efficiently. The arrester is mounted in such a way that the transformer tank is not a part of the circuit. Thus the tank can be grounded or left isolated as desired; if it be grounded it should be interconnected with the secondary neutral, so as to assure that the tank potential follows the secondary potential.

### COMMENTS CONCERNING INTERCONNECTION

Since the A.I.E.E. 1932 winter convention in New York, where the papers upon which these articles are based were presented, there has been much discussion concerning interconnection. This discussion may be more or less summarized in the statement that improvement in protection to the transformer and reduction in blown fuses will result, but where driven secondary grounds are in use, there may be some question concerning hazard. It seems to the writers that the case for interconnection versus the arrester ground connection can be stated in some such fashion as the following: With the arrester ground connection the protection of the transformer and the quality of the service depend upon the arrester, the ground resistance, and length of ground lead, while the safety of the consumer depends upon the quality of the secondary grounds. If the secondary ground resistance is high the consumer's safety also may depend upon the arrester and ground resistance as these may determine whether or not a primary-secondary contact is to be established. With interconnection the protection of the transformer depends upon the arrester only, while the safety of the consumer depends upon the quality of the secondary grounds.

Any arrangement which tends to make the secondary ground better is to be preferred, and of course this includes the interconnection of secondaries into a grid and also the interconnection of the primary neutral and the secondary neutral. Such connections establish a firm ground with many connections to ground, and should result in improved reliability both from the standpoint of lightning protection and hazard to the consumer.

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# Wiring Buildings for Good Illumination

**Progress in securing good illumination in buildings has been impeded seriously by lack of sufficient wiring capacity. The situation is reviewed in this paper in the hope of stimulating engineering interest and thus promoting wider use of practises which will insure reasonable prospect of adequacy of lighting circuits throughout the life of a structure.**

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CONTEMPORANEOUSLY with the development of lighting practise there has come into existence a group of illuminating or lighting service engineers associated with utility companies, leading lamp and equipment manufacturers, and some of the large users of light, who have interchanged data and experience with each other as well as with practising consultants.

A large measure of the effort of these engineers has been devoted to the repair and correction of lighting installations which for one reason or another have proved unsatisfactory in operation. They therefore have had an unusual opportunity of determining the border lines of satisfactory and unsatisfactory lighting. It is this experience, embodied in the criteria and rules for lighting practise, that has rendered the practise so reliable and secured its wide acceptance. While this experience has been dominantly with the smaller installations, in which for economic reasons paid consultants are not usually retained, it should be borne in mind that the more elaborate installations have at least as stringent requirements.

### LIGHTING PRACTISE ADVANCING

The lighting practises developed have been expressed in papers and reports before various associations. Notable among these are the lighting codes of the Illuminating Engineering Society, the American Standards Association, and the International Commission on Illumination. The accepted illumination levels for the most common conditions of building lighting have been compiled in tabular form by leading illuminating engineers. Among other places these tables have been published in the Franklin "red seal" specification of the Society for Electrical Development, which also prescribes approximate rules for the lighting design of the simpler and more common classes of building interiors. This specification is probably the simplest, most condensed, and most comprehensive expression of present lighting practise; thus it furnishes a reasonable expression of the electric power requirements of that practise.

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Based upon "Adequate Wiring of Buildings, an Essential for Good Illumination" (No. 32-86) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932.

While electric lighting practise in the more common applications is comparatively definite, it is not static. Illumination levels, that is to say, the quantitative elements, have been rising steadily for many years and except for the retardation during periods of business depression, there is no indication that most fields have approached saturation. Moreover, there is an increasing demand for diffusion and reduction of glare which is generally secured at a sacrifice of light and therefore puts an additional requirement on the amount of electricity to be supplied.

While qualitatively these advances are generally recognized, it is exceedingly difficult to secure any quantitative measure for them, due to variations in application, locality, time, etc. Probably the best authoritative values for industrial lighting are published in the 1921 and 1930 issues of the "American Standard Code of Lighting for Factories, Mills, and Other Work Places," which have been published in pamphlet form and in the *Transactions* of the I.E.S., v. 16, 1921, p. 362 and v. 25, 1930, p. 607. The 2 issues give the values in different form and in some instances different classifications. However, a few samples have been selected and incorporated in Table I. It is probable that in most instances the advances are, if anything, greater than here indicated as the later values were presumably more widely exemplified in actual installations at the time of issue. It seems safe to say that, in general, the decade ending in 1930 witnessed approximately a doubling of light requirement for good practise in the principal classes of commercial, industrial, and office lighting.

**Table I—Illumination Levels Good Practise**

| Class of Operation or Interior | Foot-Candles | |
|---|---|---|
| | 1921 | 1930 |
| Assembly—rough | 2 to 5 | 8 to 5 |
| —medium | | 12 to 8 |
| —medium fine | 5 to 10 | |
| —extra fine | 10 to 20 | 100 to 25 |
| Chemical works—hand furnaces, etc | 2 to 5 | 5 to 3 |
| Cloth products—light goods | 5 to 10 | 15 to 10 |
| —dark goods | 10 to 20 | 100 to 25 |
| Elevators—freight and passenger | 2 to 5 | 8 to 5 |
| Forge shops | 2 to 5 | 10 to 6 |
| Foundries—charging floor | 2 to 5 | 8 to 5 |
| —fine molding and core making | 5 to 10 | 15 to 10 |
| Glove manufacturing—dark goods | 10 to 20 | 100 to 25 |
| Locker rooms | 2 to 5 | 6 to 4 |
| Machine shops—rough work | 2 to 5 | 10 to 6 |
| —medium work | 5 to 10 | 15 to 10 |
| —fine work | 10 to 20 | 100 to 25 |
| Offices—close work | | 15 to 10 |
| —no close work | | 10 to 8 |
| —private and general | 5 to 10 | |
| —drafting | 10 to 20 | 25 to 15 |

## INDICATIONS OF WIRING INADEQUACY

For a number of years illuminating engineers have been encountering installations in which suitable lighting could not be provided because of a lack of capacity in the wiring. Even where the safe carrying capacity of the wiring was not exceeded, excessive losses of electrical pressure in the wiring were frequently encountered so that the voltage delivered to lamps was considerably less than it should have been. Such losses were greatest at times when the demand was greatest, and resulted in serious reduction in light output and lamp efficiency. In a brief survey made in 1931 by an electric utility company in Ohio, it was found that the voltage drop in the interior wiring between meter and socket was frequently over 5 per cent and in some cases in excess of 10 per cent. Since operation of tungsten filament lamps at 10 per cent of rated voltage means a light output of only about 70 per cent of normal (see Fig. 1), it is easy to understand how unsatisfactory the illumination would be. This subject is discussed further in "Voltage and Incandescent Electric Lighting," G. S. Merrill, Preprint No. 137, International Illumination Congress, presented at Glasgow, September 1931. Oftentimes such conditions have been misinterpreted as being due to poor regulation of the utility's circuits or to defective lamps and have been a source of complaint from this standpoint. In extreme cases building owners have been compelled to incur the costly outlay of rewiring, but in a much larger number of cases, the expense has appeared prohibitive, and unsatisfactory lighting has been continued.

A review of the papers and reports presented before engineering associations shows careful treatment of practically every phase of electrical engineering except building wiring. It seems important that more attention be given this subject.

## FUTURE LIGHTING

In addition to the expected advance in illumination levels and degrees of light diffusion, there is a number of more or less new lighting applications going into use which bid fair to increase the electrical consumption. Among these may be mentioned light ornaments, that is, light sources to look at rather than for general illumination, ornamental portable lamps, indoor signal indicators, signs, etc. Some of these, while originating in the home, club, or hotel, are spreading to stores, offices, and other interiors.

For the past 5 years, the practise initiated in Europe of using so-called "built-in" lighting has been spreading rapidly in this country. Since such lighting formerly required special construction in the walls and ceilings, it was applicable only to new buildings or those in which extensive reconstruction was being undertaken. However, modified forms of luminaires similar to built-in equipment are beginning to appear, and these can be installed without difficulty in finished rooms and supplied from the usual electric outlets. This class of lighting is extending because of its artistic merit and in spite of a considerable reduction in efficiency measured in lumens per watt. It therefore represents an increase in electrical consumption which should receive proper consideration.

Another phase of lighting, which is still in the experimental stage but receiving enough attention to preclude ignoring it, is the so-called "dual purpose" health lighting. In addition to the visible light, these lamps supply the ultraviolet radiation which is depleted from daylight by window glass and city smoke and which is absent from the light of ordinary illuminants. Such equipment does not inherently require more electricity per unit of light than ordinary lighting, but the installations so far made indicate a tendency to employ higher wattage.

A compensating factor to the increased consumption would be the use of more efficient light sources. The rapid increase in efficiency of incandescent lamps from, say, 1912 to 1922 just about kept pace with the demand for more light, so that the electrical demand for a given area and purpose held fairly constant throughout that period. Since then the advance in efficiency has slowed down and although illuminants of considerably higher efficiency have been produced in laboratories, it appears unsafe to depend upon any great increase in efficiency being widely applicable to today's installations within the next 4 or 5 years.

Within the past 10 years large numbers of small motor and heating appliances have been connected to lighting circuits and apparently the next few years will witness considerable increase in the load due to their more extended use. They are valuable services and must be planned both for their own value and for the limits they otherwise would present to good lighting practise.

## THE QUANTITATIVE ELEMENT OF WIRING

Interior wiring has received a great deal of attention on the part of code writers, and has been the subject of numerous rules. By many in the electrical industry the National Electric Code has been taken as a standard of good engineering, overlooking the fact that the purpose of the code is fire prevention and other safety features. Being mandatory in character, the code cannot prescribe wiring on the basis of economic engineering. Because of the common failure of those responsible for such wiring to provide for later additions to the load it has been necessary for the code to anticipate these additions, but still on the basis of safety only. The code has been the subject of considerable controversy among the various interests involved. Since good engineering would incorporate both the requirements for safety and economic operation, there is good reason to believe that if good engineering were to prevail in this field these misunderstandings would disappear and the code assume its rightful position.

In the absence of generally accepted standards other than the wiring code, it has become a widespread practise for designers to establish arbitrary rules and constants of their own making. In the smaller installations the details of wiring are often determined by competing contractors eager to underbid each other. Where consulting engineers are retained, they often are urged to justify their employment by minimizing investment and so find it difficult to apply best engineering judgment. These varying circumstances all militate against the proper response of wiring practise to the needs of lighting.

In the report of a National Electric Light Association subcommittee on adequate wiring entitled, "Lighting Service Manual," Part 3, p. 17, published by the N.E.L.A., August 1928, the following conclusions were drawn:

1. That to cut down the wiring specifications in order to reduce the initial investment was false economy as the greater losses would within a period of a year or 2 entirely offset the difference in investment.

2. That the investment in the wiring system did not increase in direct proportion to the increase in wiring capacity; doubling the wattage capacity increased the investment only about $^1/_3$ while 50 per cent extra capacity meant an additional investment of only from 15 to 18 per cent.

It would appear therefore that in the interest of good engineering based upon economics what is needed is a reasonable standard, based upon good lighting practise, with an allowance for advances in the art and probable changes in the use of buildings. Such a standard would do much to overcome the insidious whittling which, in a considerable degree, has been responsible for the unsatisfactory condition.

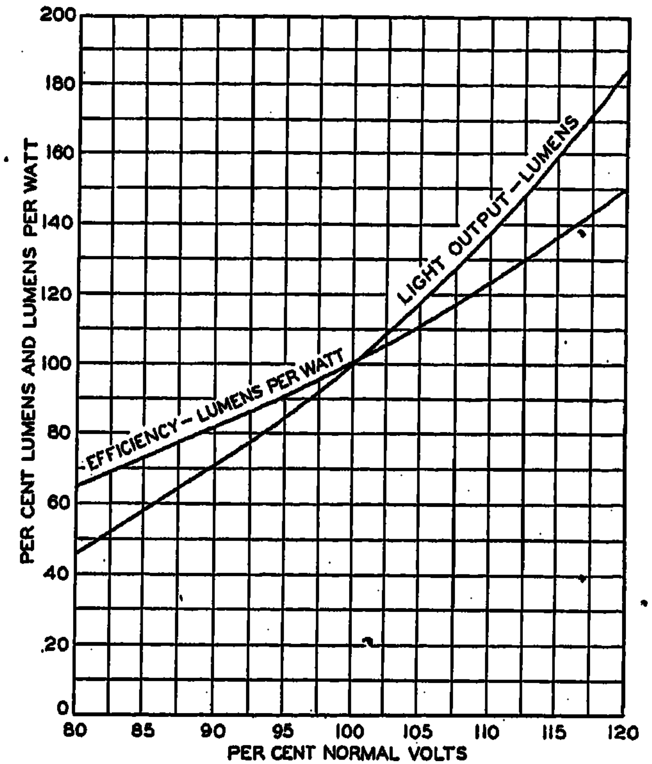

**Fig. 1. Relation between illumination and voltage of tungsten filament lamps**

## ADEQUACY SPECIFICATION

A few illumination engineers about 1924 became conscious of building wiring as a limitation of good lighting. Previous to that time these engineers had concentrated upon the selection of lamps, luminaires, and locations. It became obviously important to give attention to wiring if the advance of illuminating engineering were not to be seriously impeded. The educational undertaking which resulted is described in "Adequate Wiring—A Problem of the Illuminating Engineer," G. H. Stickney, Preprint No. 125, International Illumination Congress, presented at Glasgow, September 1931.

Through the efforts of the N.E.L.A., preliminary paragraphs for an adequacy specification were agreed upon in the spring of 1929. Immediately some of the illuminating engineers, especially those associated with electric utility companies, began an informal application of the standards so embodied. The results were very gratifying. After a year's experience an extension of these paragraphs for commercial buildings was published by the N.E.L.A. in the pamphlet of March 30, 1930, entitled, "Minimum Specification for Adequate Wiring of Lighting Circuits in Commercial and Public Structures." A corresponding specification for industrial buildings was issued under the same auspices on July 20, 1931, entitled, "Minimum Specification for Adequate Wiring of Lighting Circuits in Industrial Structures."

Several interested groups individually undertook the preparation of corresponding specifications for residence wiring, and in the fall of 1931 an industry committee was organized to coordinate the several undertakings into a single standard specification. This work is not yet completed, although the reports indicate that the end is in sight.

It is to be hoped that consulting engineers will familiarize themselves with these specifications and subject them to criticism, and that out of this there may come generally accepted standards of wiring practise. This would strengthen the weak link in the system of electric lighting, and encourage a normal development along the line of good engineering based upon economics. The public then could look with confidence to its advisers in the field of electric lighting, and be assured that good illumination, according to its needs, could be had in any building constructed under responsible auspices.

# A Railway Motor Without Commutator

**One of the latest uses for that versatile device, the grid controlled mercury arc rectifier, is to replace the commutator of an electric railway motor that will operate on either alternating or direct current. However, the rectifier eliminates not only the commutators in a locomotive equipped with these motors, but also all expensive control, switching, and reversing equipment. Experiments have shown so much promise that a 1,000-hp locomotive of this type now is being built in Switzerland.**

By
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EXTENSIVE research work carried on for improving the mercury arc rectifier has led not only to improvements in its operation but also to entirely new applications of the device, and to new applications of the valve action on which its rectifying property is based. In recent years considerable experimental and development work has been carried out on rectifiers provided with control grids, utilizing the grids for interrupting short circuits and backfires, for d-c voltage control, for the conversion of direct current to alternating current, and for many other purposes. In this paper is described a new application of grid controlled mercury arc rectifiers in connection with a new single-phase commutatorless motor for a-c railway service.

Experiments carried out on a locomotive equipped with this type of motor have demonstrated the practicability of this scheme. Besides the elimination of commutators, practically all of the expensive switchgear and control apparatus is done away with, resulting in a simplification of the locomotive and a reduction in cost. In addition, it becomes possible to use a power supply of any available frequency, whereas at the present time frequencies of 25 cycles or less generally are required. While it is too early to predict where this development may lead, the marked advantages of a locomotive equipped with motors of this type, which are already apparent, may revolutionize the practise of railway electrification.

## OPERATION OF ENERGIZED GRIDS

Phenomena and characteristics of the mercury arc valve have been treated in great detail in various scientific journals. Its applications are many if equipped with a control grid which is introduced into the path of the arc. This grid is insulated from the anode and may be energized from an outside source of potential, such as a battery, auxiliary transformer, generator, or a combination of these sources. Non-energized grids or screens also are used to a large extent in mercury arc rectifiers for many purposes. (See "Mercury Arc Power Rectifiers," Marti and Winograd, McGraw-Hill Book Co., p. 42, 227, 232, 397.)

Some of the possibilities of energized grids are illustrated by the diagram of a 2-anode rectifier shown in Fig. 1. Let a sinusoidal a-c voltage be impressed on the primary side of the transformer, and let the grids be de-energized. The anodes will be positive during alternate half-cycles. During the half-cycle that anode 1 is positive, current will flow from anode to cathode through the load circuit, as indicated by the solid arrows. When anode 2 is positive, current will flow from anode to cathode through the load circuit, as shown by the dotted arrows. The current therefore flows through the load circuit in the same direction during both halves of the cycle. The same rectifying action will take place if a positive potential is applied to the grids during the intervals when the voltages of the corresponding anodes are positive. This could be accomplished by throwing switch *S* (Fig. 1) from one position to the other after each half-cycle, making the grid of anode 1 positive during the half-cycle when anode 1 is positive, etc., or by rotating commutator *C* at synchronous speed by means of motor *M*.

This is illustrated in Fig. 2. Section *a* shows the

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Based upon "The Mercury Arc Rectifier Applied to A-C Railway Electrification" (No. 32-63) presented at the A.I.E.E. Great Lakes District meeting, Milwaukee, Wis., March 14-16, 1932, and subsequently revised and brought more fully up to date.

anode voltages $e_{10}$, $e_{20}$. Shaded portions represent the d-c voltage wave (neglecting the arc drop). Section *b* represents the d-c wave for a resistance load. Sections *c* and *d* indicate the potentials applied to the grids; shaded blocks represent the potentials if direct current is used, with a reversing or rotating switch, as shown in Fig. 1, and the sine waves represent the potentials if alternating current is used.

In *A* of Fig. 2 is shown the condition when the grids are made positive at the instant when the corresponding anodes become positive. Each anode then operates during half a cycle, and the average d-c voltage is shown by line $E_{dA}$. In *B* of Fig. 2 is shown the condition obtained by shifting the brushes of the rotating switch *C*, Fig. 1, through the angle $\alpha$. The grid potential then becomes positive $\alpha$ electrical degrees after the anode potential, and the point at which the anodes start firing is delayed by the angle $\alpha$, which reduces the d-c voltage to the average value $E_{dB}$.

It can readily be seen that by shifting the brushes of commutator *C*, that is, by changing the timing with respect to the voltage of the anodes, the rectifier can be stopped from passing current without interrupting the primary supply or the voltage can be changed from the maximum value $E_{dA}$, to a value $E_{dB}$, or can be made as low as zero. The source of potential for energizing the grids, battery *B*, can be replaced by an a-c source, which could be an auxiliary transformer, a small generator, or the like. Several standard rectifiers equipped with such grid control have been built at the West Allis works of the Allis-Chalmers Manufacturing Company and recently were placed in service. They have proved entirely satisfactory.

Only a few hundred watts are required for controlling power rectifiers. The grid control apparatus is therefore quite inexpensive. This fact should be born in mind when studying the commutatorless motor and locomotive described later in this article.

## INVERTED RECTIFIER

In the arrangement shown in Fig. 1, assume that the load is replaced by a d-c generator as shown. If a positive voltage is applied to the grid of anode 1, current will begin to flow through the left-hand portion of the secondary winding of the transformer, inducing a voltage in the primary winding. After a certain time interval let the grid of anode 2 become positive, and current will start to flow through the right-hand portion of the secondary winding of the transformer. If at the same time the current in anode 1 can be reduced to zero by some means or other, then the rectifier and associated equipment would be nothing else than a converter feeding power from the d-c into the a-c network. Although the flow of current from generator *G* through the anodes can be controlled by energized grids only as to the time of starting, other methods have been developed for reducing the anode current to zero in the proper sequence to obtain inverted operation of a conventional rectifier so as to convert direct current into alternating current. (See Kern, *Bulletin Schweizerischer Elektrotechnischer Verein*, 1931, p. 538.)

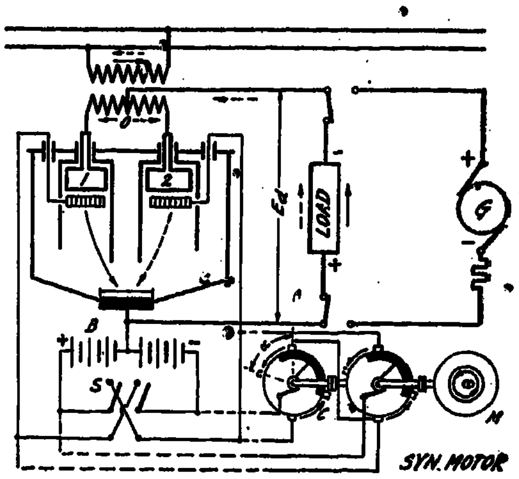

**Fig. 1. Controlled-grid valve that can be used either as a rectifier or a d-c to a-c converter**

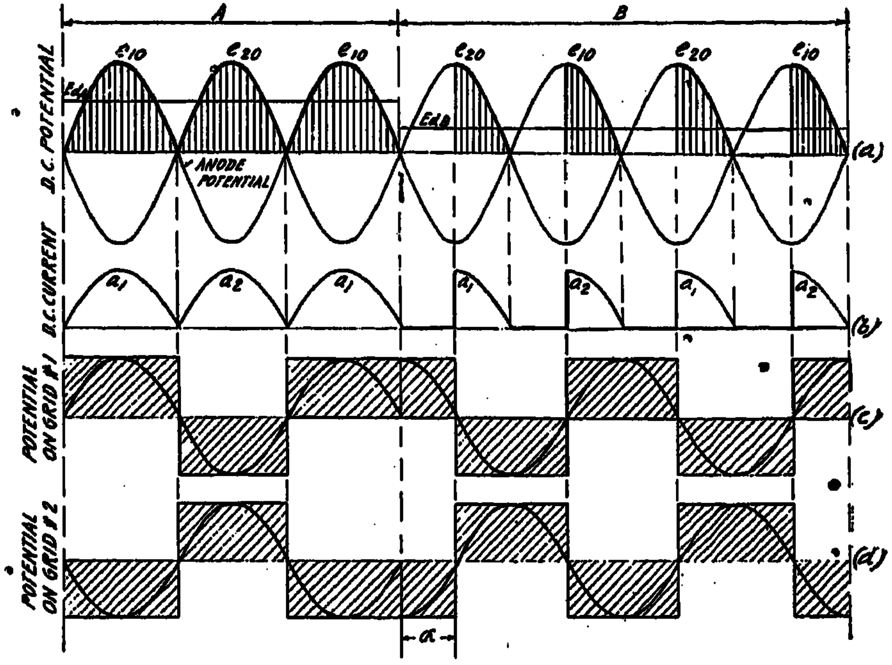

**Fig. 2. Curves illustrating voltage regulation and control by means of energized grids**

This feature opens up great possibilities for the now fully developed mercury arc rectifier, and many new applications for the mercury arc valve.

## COMMUTATORLESS SINGLE-PHASE RAILWAY MOTOR

For some time portable substations equipped with mercury arc rectifiers have been built abroad and in this country. As far back as 1914 a 250-hp motor car, equipped with a mercury arc rectifier, was in service in this country, on the New York, New Haven, and Hartford Railroad. As some experience therefore already is at hand, it will not be a novelty to put a rectifier on a locomotive, except in its use as a static commutator for the traction motors.

Present standard series a-c or d-c traction motors are limited to comparatively low voltages by their commutators, and therefore the controls for these motors are expensive. The commutator also makes the construction of the motor expensive, and involves the troublesome difficulties inherent in mechanical commutation. It has been found possible to replace the commutator by a series of electric valves, *viz.*, a mercury arc rectifier, by the use of which the disadvantages mentioned are obviated. This scheme can be applied to single-phase or d-c motors so that relatively high voltages can be used, thus reducing the size and weight of the copper used in the connections. At the same time, a very desirable speed-tractive effort characteristic can be obtained. Furthermore, all expensive control, switching, and re-

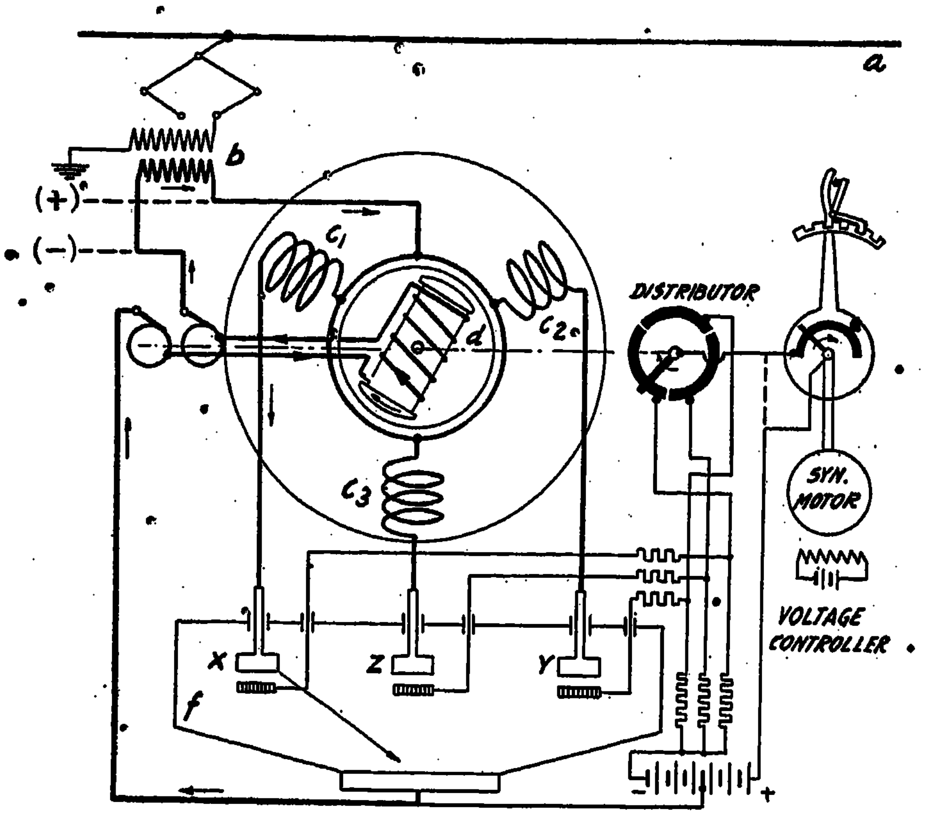

**Fig. 3. Elementary commutatorless motor**

versing equipment is dispensed with, while a rectifier and a very simple and cheap grid control is added.

Referring to Fig. 3, it may be seen that the commutatorless motor consists of an armature winding $c$, a field winding $d$, and a distributor mounted on the shaft of the motor. An integral part of the motor is the grid controlled rectifier $f$. The complete outfit includes, in addition, a single phase transformer $b$, a synchronous rotary switch, and the control battery; $a$ is the trolley wire. The armature windings of the motor are in the stator and the field winding is on the rotor for the same reason that this practise generally is followed in the design of synchronous motors. By doing so only 2 slip rings are necessary for the field windings, whereas if the armature were wound on the rotor 4 slip rings would be required in this particular case, and even more for practical applications.

In order to understand the function and operation of the distributor, assume for a moment that the armature is on the rotor and that the field is in the stator. The distributor then corresponds exactly to the conventional commutator of a d-c machine, that is, it distributes or shifts the current from one armature coil to the next at the proper moment, just as the conventional commutator does in a conventional motor. However, instead of carrying the total armature current, or, as in a series motor, the total motor current, the distributor has to handle only a very small current—a fraction of an ampere; it controls the rectifier which carries the full motor current and performs the actual commutation. Now, considering this motor again as it actually would be built with the armature stationary and the field fed by slip rings, it is evident that the distributor still performs the functions of a commutator. In other words, the distributor controls the flow of current through the various coils of the armature winding as a function of the position of the rotor just as a conventional commutator would do the same thing, and has no effect on the speed of the motor.

In operation, let it be assumed, first, that the rectifier equipment is in the position shown, and that one grid (of anode $x$) is energized positively through the distributor. This grid accordingly permits current to flow through the anode which it controls. All other grids will be energized negatively thus preventing current from flowing through their anodes. As the primary winding of transformer $b$ is energized from the line, a half-wave current will flow through the winding of rotor $d$ and through $c_1$, as indicated by the arrows. As can readily be seen, the field produced in the windings $c_1$ and $d$ will produce a torque which causes the field $d$ to rotate. At the proper time, the shaft of the motor $e$ brings the brushes of the distributor to such a position that the grids of anodes $z$ and $x$ now are energized negatively, while the grid of anode $y$ is energized positively, permitting current to flow from anode $y$ into winding $d$, and through $c_2$. This process is repeated in sequence for all windings of the stator, thereby producing a continuously rotating motion of the rotor.

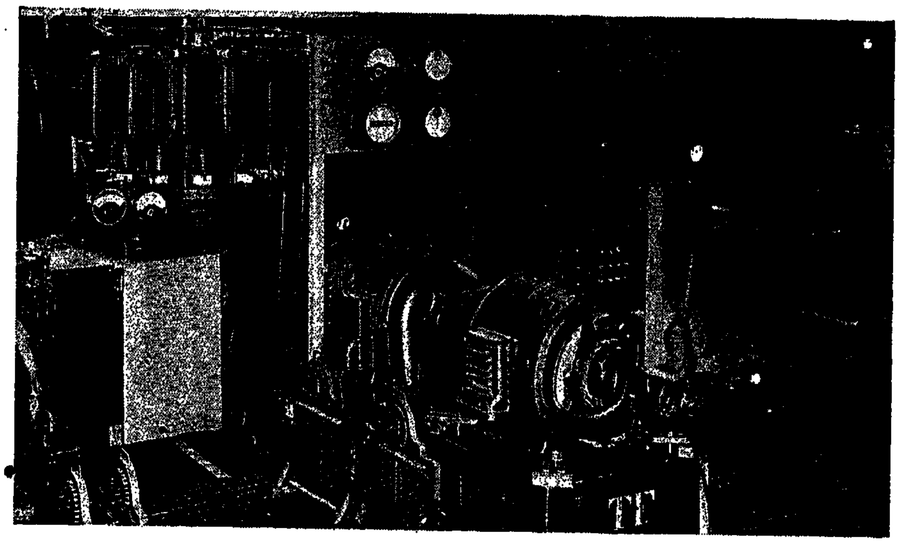

**Fig. 4. Commutatorless rectifier motor on test**

## CONTINUOUS SPEED CONTROL

The speed of the motor is determined by the same factors which determine the speed of any series motor, whether d-c or a-c, namely, the load on the motor and the voltage across it. In the case of a d-c series motor, the voltage across it would be determined by the series resistance, which can be cut in or out in steps; a-c series motors are controlled similarly by means of resistances or taps on an auto-transformer. Both of these schemes have their obvious disadvantages as follows:

1. The speed is regulated in steps.
2. A considerable loss in energy generally is involved.
3. The control apparatus is expensive, becoming more expensive as the number of steps is increased.

In the commutatorless motor, continuous speed regulation can be obtained without loss of energy and with inexpensive equipment. In Fig. 3 may be seen a rotary switch called the voltage controller, driven by a small synchronous motor from the main supply. This voltage controller prevents the formation of an arc in the rectifier before a certain point in the cycle of the voltage wave. This point can be determined by shifting the position of the stationary contact of the voltage controller so that the anode can be made to pick up at the very beginning of the positive half of the voltage wave, or can be entirely prevented from picking up. Any intermediate position, of course, can be obtained. Referring to the explanation of voltage control of rectifiers by means of energized grids, it may be seen that actually the average voltage across the motor is being controlled. By this mean speed regulation of the motor is obtained, and it is evident that this regulation is continuous from zero up to the speed for which the motor is designed. It is evident also that the same voltage controller can be used for starting the motor.

The motor illustrated in Fig. 3 utilizes only one half of the applied voltage wave, and hence would not be considered in a practical case. A connection therefore is used whereby the full wave is utilized. Moreover, the armature windings are arranged so that although each conductor carries only a pulsating unidirectional current, each pole is energized continuously for 180 electrical rotor degrees in one direction, and in the other direction for the next 180 degrees. Magnetic conditions in the motor therefore are the same as in a d-c machine, and there is no tendency for the motor to "lock in" at synchronous or sub-synchronous speeds.

This motor has a series characteristic which is desirable for traction purposes. A resistance can be connected across the stator winding, so that the motor can be given the characteristics of a repulsion motor. It is also possible to connect only the rotor to the source of power, in which case the stator circuits are closed only through the rectifier, and the stator currents are obtained by induction through the rotor. The stator, being then no longer connected to the circuit, can be wound for whatever voltage is found most desirable. (See Kern, *Elektrische Bahnen*, November 1931.)

## Motor Can Operate From Direct Current

Considering the magnetic conditions in the commutatorless motor, it can be shown that a motor can be designed to operate from a d-c source. The counter emf is used to enable the rectifier to commutate the current from one armature winding to the next. During the starting period, before sufficient back emf is available, a small auxiliary machine supplies the commutating voltage. It is possible to design a motor which will operate either on 25 or 60 cycles, or on direct current. A locomotive therefore can be designed which will operate on, say, 11,000-volt, 25-cycle main lines, and also on 3,000-volt d-c systems in metropolitan areas.

Summarizing, we have a motor which can be used either on 25 or 60-cycle systems or on high voltage direct current. Starting and controlling the motor is effected by controlling the average d-c voltage across the motor without loss of energy. The motor is reversed merely by shifting the stationary contacts of the distributor 180 electrical degrees. Regenerative braking is obtained by shifting the distributor and voltage regulator. Thus all control operations, starting, running, reversing, and braking of the loco-

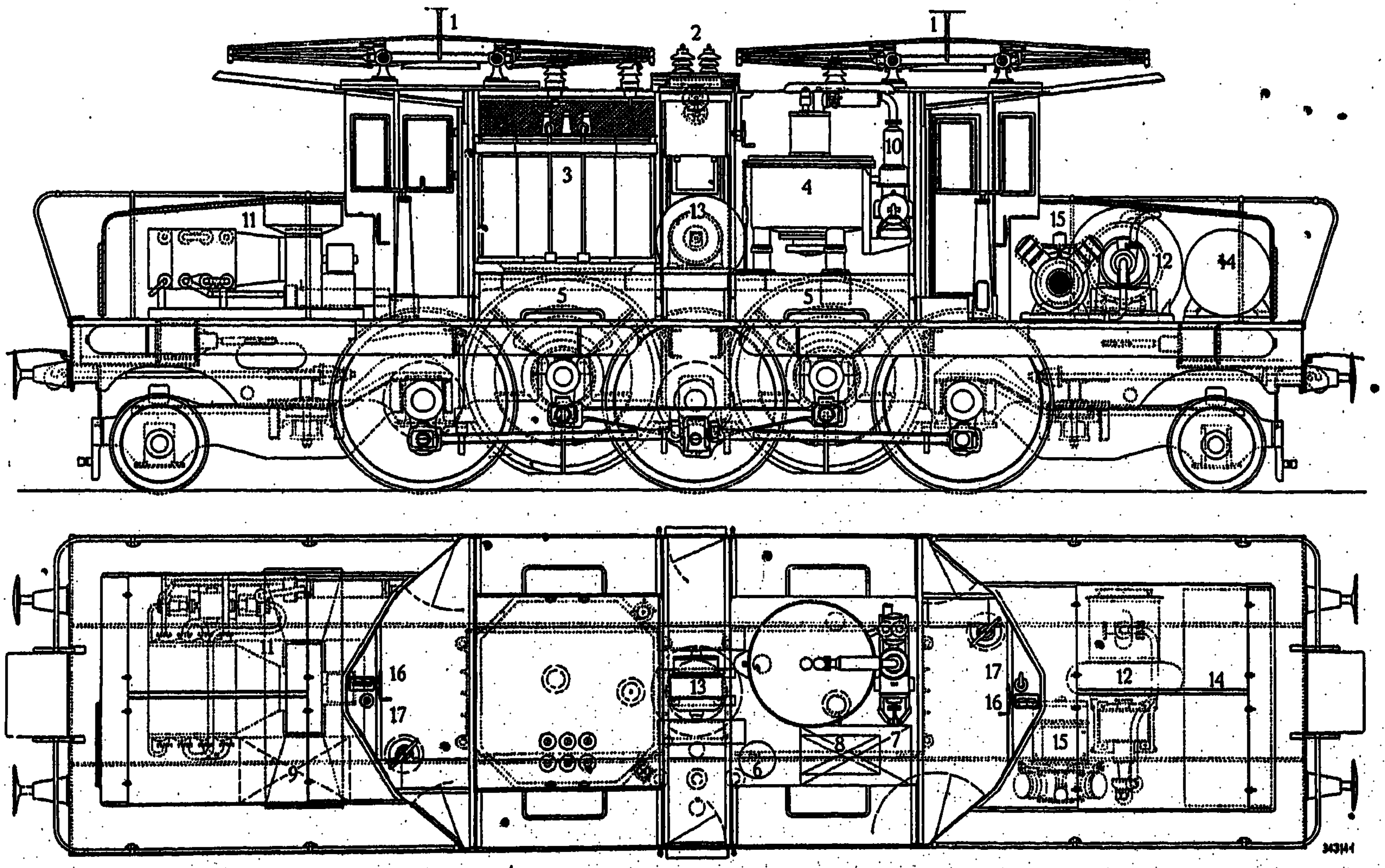

**Fig. 5. General layout of 1,000-hp single-phase test locomotive with rectifier grid-controlled motors**

1. Current collector
2. Main switch
3. Transformer
4. Rectifier
5. Traction motors
6. Control button
7. Main controller
8. Voltage controller
9. Motor switch
10. Vacuum pump for rectifier
11. Cooling set for rectifier
12. Cooling set for transformer
13. Fan for traction motors
14. Converter for auxiliary services
15. Air compressor
16. Master controller
17. Reversing switch for running and recuperation of power

motive, are accomplished by shifting the stationary contacts of the voltage controller and of the distributor, both of which are small pieces of apparatus.

In Fig. 4 is shown the first experimental model of such a commutatorless motor directly coupled to a generator as load, and with a commercial rectifier of large capacity. The control hand-wheel is visible on the right.

In conclusion it is of interest to note that Brown, Boveri & Company, Ltd., of Baden, Switzerland, at present is building a single-phase locomotive to be operated directly with single-phase power of 50 cycles at 15,000 volts. The locomotive is of standard gage, and is equipped with two motors of 500 hp, one-hour rating, for a maximum speed of 90 km per hr (56 mph). (See Fig. 5.) It is designed for regenerative braking. This locomotive has no commutators, tap switches, starting resistances, or reversing switches, in the motor circuit. All such equipment is replaced by a high-voltage mercury arc rectifier with control grids. Tests with this locomotive will be highly significant in view of the possible utilization of alternating currents of commercial frequencies for the electrification of main line railroads.

# The Rock Island Hydroelectric Development

**First electric power development on the famous Columbia River, the initial 60,000-kw Rock Island plant also is the first major low head installation on the Pacific Coast, a territory long famous for its high head plants, and has the largest installed capacity in adjustable-vane propeller-type wheels of any plant in the United States. Some of the project's many departures from conventional design are revealed in the accompanying text and illustrations.**

By
A. P. NEWBERRY

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MEMBER A.I.E.E.

Both of
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THE ROCK ISLAND hydroelectric plant is being built as a unit of the Puget Sound Power & Light Company's system which supplies electric service to a large territory lying west of the Cascade Mountains in the State of Washington. The development is interesting in that it is the only large low head plant in a section where high heads are the rule and therefore presents certain features of design that generally are not found on the Pacific Coast. Further, it is the first step in the development of the enormous power resources of the Columbia River, one of the most famous streams in North America.

The plant is located east of the Cascades on the Columbia River in central Washington about 13 miles downstream from Wenatchee. From the plant 2 130-mile 110-kv transmission lines cross the mountains through widely separated passes to connect at different points with the company's system around Puget Sound where the major portion of the station's output will be used. The main power supply of the system at present is from hydro plants on the west side of the mountains supplemented by a relatively new 80,000-kw steam-electric generating station in Seattle. While there is some diversity in the various rivers due to the different altitudes of their watersheds, they all have the characteristics typical of glacially fed streams, high water in the spring and summer and low flow in the fall and winter. Even with appreciable amounts of storage available to fill in the low periods, there is a natural reduction in hydro capacity at those times requiring the operation of steam stations to make up the deficiency. Conditions at Rock Island are such that, with maximum capacity and output available at low water and the reduction in both occurring at high water, this plant fits in admirably with the other stations.

## WATER SUPPLY

The Columbia River at the dam is fed by a drainage area of some 90,000 square miles extending from the Cascade Mountains on the west to the Rockies on the east, and including parts of Washington, Idaho, Montana, and British Columbia. Precipitation in the upper Columbia watershed varies from less than 15 in. in eastern Washington to nearly

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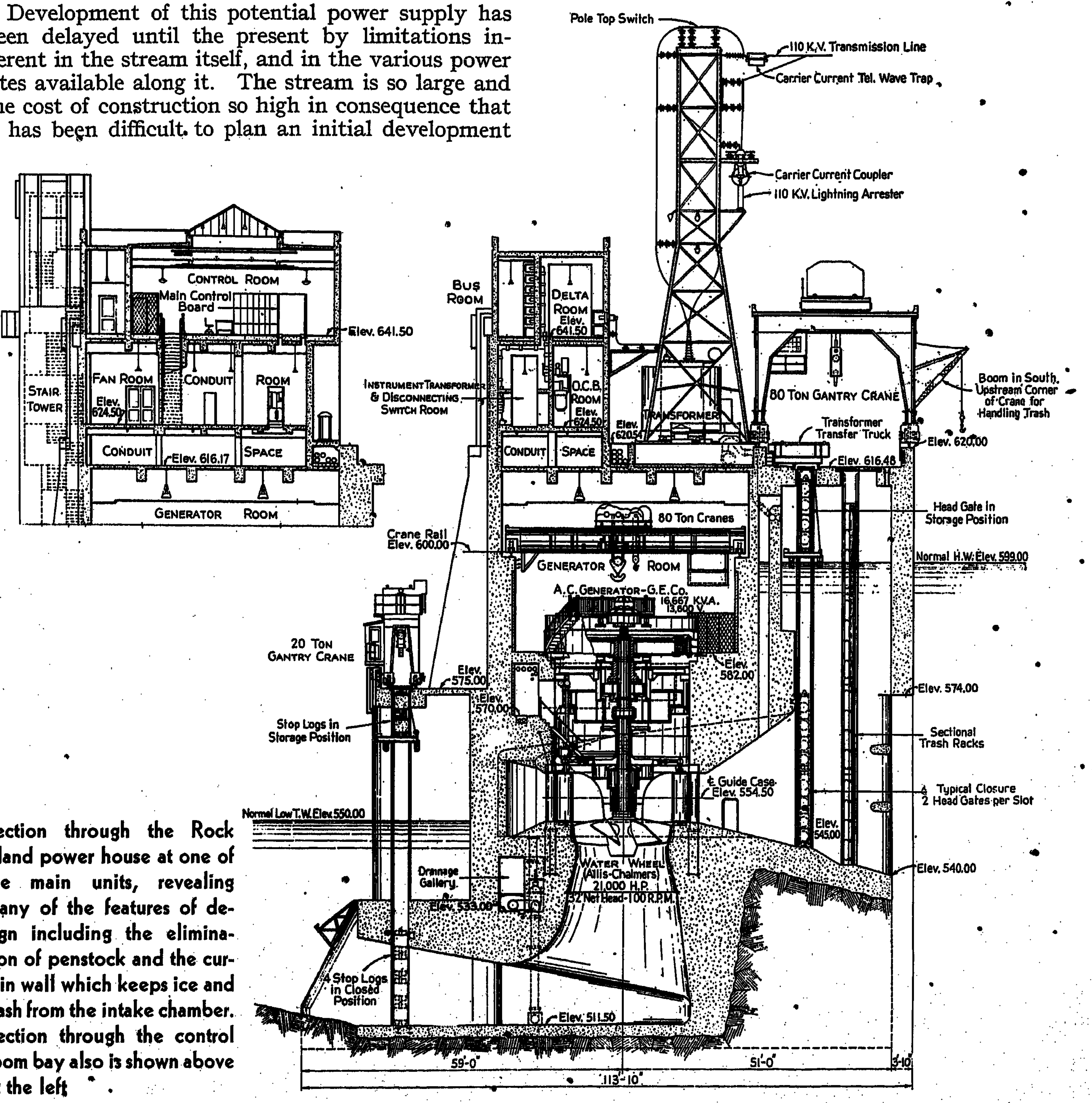
Full text of a paper presented informally at the A.I.E.E. Pacific Coast convention, Vancouver, B. C., Aug. 30–Sept. 2, 1932, as enlarged and rewritten especially for ELECTRICAL ENGINEERING through the cooperation of the Stone & Webster Engineering Corporation, Boston, Mass. *Not published in pamphlet form.*

100 in. in British Columbia. This upper portion of the drainage area includes many lakes and glaciers, and mountain ranges almost perpetually covered with snow. Nearly all the precipitation on the entire watershed comes in the winter in the form of snow which lies on the ground until spring. Hence from October 1 to April 1 the supply is almost entirely ground water, maintaining a remarkably uniform flow averaging about 40,000 cfs and rarely exceeding 100,000 cfs. As the snow melts, beginning usually about April 1 on the lower lands and gradually extending to the higher levels, there is a discharge steadily increasing to a maximum about the middle of June. This maximum varies widely from year to year depending upon the amount of snow in storage and the rate of run-off. The maximum flood on record since 1858 was 740,000 cfs in 1894; the lowest recorded flow about 21,000 cfs.

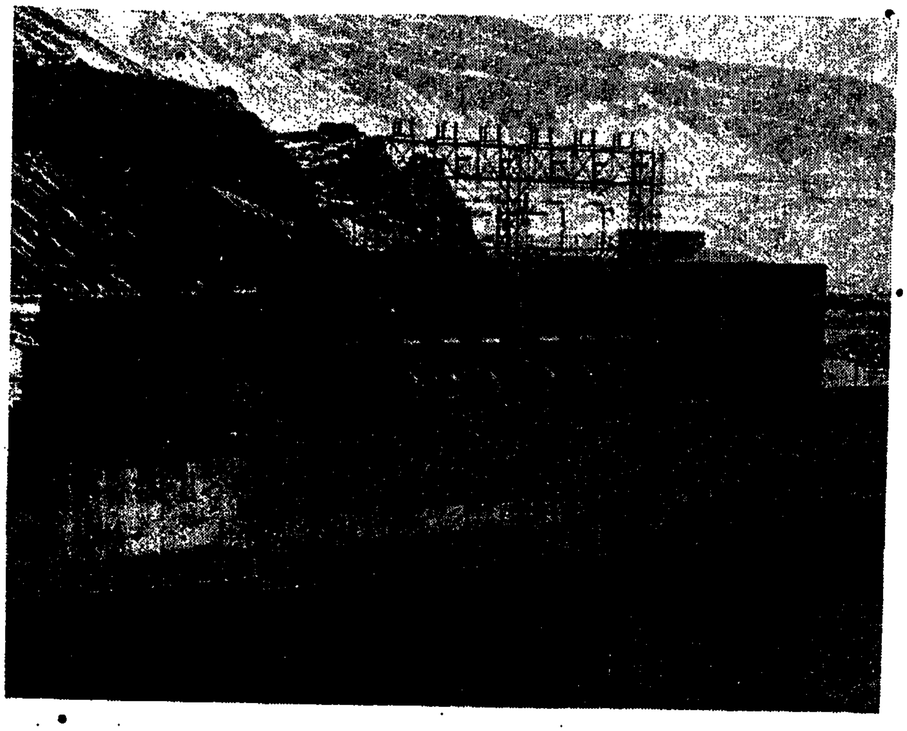
Development of this potential power supply has been delayed until the present by limitations inherent in the stream itself, and in the various power sites available along it. The stream is so large and the cost of construction so high in consequence that it has been difficult to plan an initial development that would show good economy. The opinion generally held has been that any Columbia River water power development would require a market larger than could be furnished by any one of the adjacent power systems. Further, the nature of the river channel below the dam is such that, with increasing flow, the water level below the dam rises much faster than the level above, until, with extreme floods, the differential may be less than 20 ft. However, this reduction in head and consequently in plant capacity, comes at a time when all other plants on the system are at their best in productive capacity, and therefore is not a handicap to economical operation.

The Columbia basin in eastern Washington is underlaid by basaltic formation made up of separate layers or flows of lava superimposed one above the other. In general, these layers are horizontal and



**Section through the Rock Island power house at one of the main units, revealing many of the features of design including the elimination of penstock and the curtain wall which keeps ice and trash from the intake chamber. Section through the control room bay also is shown above at the left**

in much the same position as when first deposited. One of these sheets of basalt forms the rapids at Rock Island, and is the foundation on which the dam is built. (See front cover.) Chief among the advantages that led to the selection of this location are (1) good foundation and favorable topography; (2) proximity to a transmission line already constructed; (3) site on the main line of the Great Northern Railway; (4) amount and character of available power is such that it can be utilized economically by the power company.



Upstream view of the Rock Island power house showing the outdoor transformers with associated forced air cooling equipment

THE DAM

The dam is a concrete structure built to develop an effective head of 32 ft at its initial height. Ample water is available for full capacity of the present installation at that head, but with the addition of more units the dam will be raised to give an effective head of 48 ft. Spillway capacity sufficient to pass extreme floods is provided by 37 gates each 30 ft wide, 18 of which have their sills at el 559.0, and the remainder at el 581.5. In the initial development a free crest at el 581.5 will be maintained by using gates to that height in the deep slots, except in very high water when some of these gates will be opened to hold the pond level within the project boundary. With the installation of more units, piers will be raised and gates placed to el 599.0 to provide the 48-ft head.

Requirements laid down by the Federal Power Commission in its construction license covering the project called for a design that would provide immediately for the free passage of salmon over the dam, and provide ultimately for the possible development of the upper Columbia River as a navigable stream. At present there is extensive navigation in the lower regions of the river, particularly from Portland to the Pacific, but the degree to which the river is navigable diminishes upstream because of the increasing number of rapids, and reefs which offer serious obstruction to free navigation. Contemplated future possible improvements of the upper portion of the river are based upon plans for securing slack water navigation by means of a series of locks and dams. When completed to its ultimate height the Rock Island dam will provide a navigable pool about 14 miles long at low water. To permit the possible use of this pool for navigation, the structure has been so designed that a lock could be constructed on the river bank opposite the power house in place of a portion of the present abutment.

Perhaps one of the most interesting features of the development is the pair of fish ladders provided for the passage of salmon which are going upstream in varying quantities at practically all times. Because of the importance of maintaining the fish run, careful study was given the problem of getting them over the dam until final plans were worked out in conjunction with state and federal authorities and a ladder was constructed in each abutment. Each of these ladders is some 500 ft long and provides 45 steps each 1 ft high, 10 ft long, and 20 ft wide. Sufficient water is used to assure a depth of more than a foot over the weirs, thereby permitting the fish to swim readily from one pool to the next rather than forcing them to jump. It is almost impossible to see the fish progress through the ladder, but the presence of a normal number of salmon at points up the river indicates satisfactory operation.

POWER HOUSE

The power house, also of concrete, is built into the dam adjacent to the north abutment and, while the present building will accommodate only the initial 4 units, the foundations are in for the ultimate 12 turbines which will require a building 880 ft long. That the power house design embraces several unusual features may be seen from the accompanying illustrations. Perhaps one of the most interesting of these arises from the necessity of providing for the possibility of extremely high tailwater by eliminating from the building all windows and other exterior openings below the main deck, which is about on a level with the roof of the generator room. In the office bay and the control room, located above the deck, the design provides for the normal proportion of windows, but throughout the plant excellent working conditions under close control are provided by artificial illumination and forced ventilation.

Air conditioning equipment is installed in connection with the ventilating system and even with the extremes of temperature of the eastern Washington climate satisfactory temperature control is obtained. Winter heat is provided by drawing warm air from the generators and forcing it to all parts of the building with blowers, together with sufficient air drawn in from the outside to keep conditions at the proper point. In summer the generators are closed and their heat absorbed by air coolers, and fresh air after being properly conditioned is circulated throughout the entire building. In addition to the ventilating and lighting system there is a complete system of tile drains laid in the substructure walls to intercept seepage through them and convey it to a sump whence it is removed by pumps.

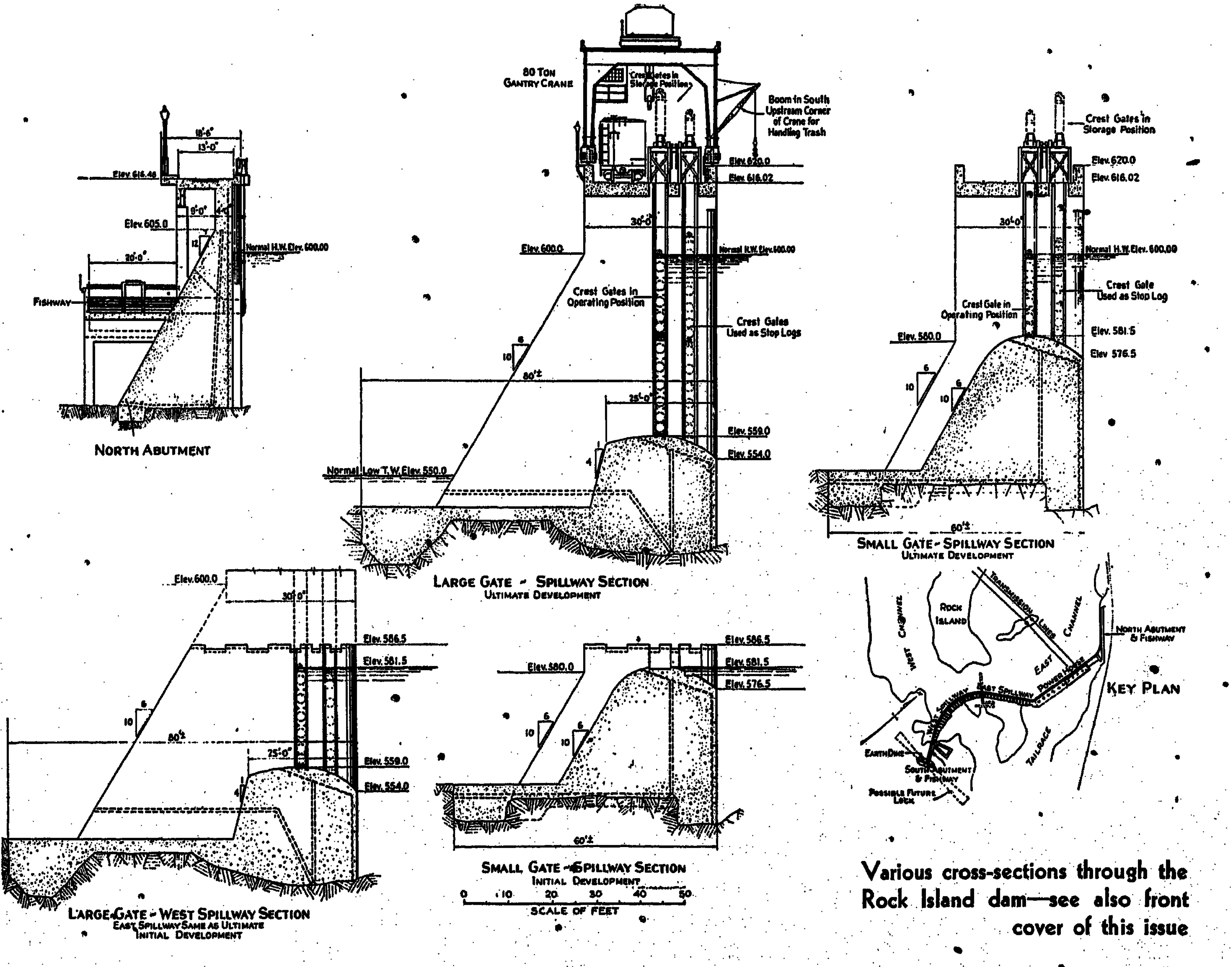
### WATERWHEELS

Waterwheel equipment as selected for the Rock Island plant has been designed to enable the production of as much power as possible under a reduced head, and at the same time to enable operation under normal conditions without an excessive decrease in operating efficiency. These wheels will develop 21,000 hp, equivalent to normal generator capacity, under a head of 32 ft, although they are designed to operate efficiently under a head of 48 ft. Each wheel will produce about 9,500 hp under a 20-ft head.

The initial installation consists of 4 vertical shaft units rated 21,000 hp at 32-ft head. These wheels are of the propeller type, with adjustable vanes selected because of the low and varying head conditions, and they constitute one of the largest installations of this type in the United States. The cast steel runners are 18.75 ft in diameter, are designed to operate at 100 rpm under heads varying from 20 to 48 ft, and carry 6 vanes each. To maintain capacity as high as possible at low head, and efficiency as high as possible at high head, the vanes are adjustable by means of a geared operating shaft which extends up through the hollow turbine shaft to the coupling between the turbine and the generator. Adjustments can be made only with the machine at rest, when changes may be made in from 5 to 10 min with the aid of a portable air motor. To protect the gear mechanism from water the runner hub and the gearbox are filled with a cup grease kept under high pressure.

The reinforced concrete scroll case for each wheel is directly connected to an intake opening in the face of the dam, and each opening is divided into 3 headgate sections each 27 ft 11 in. high by 15 ft 4 in. wide. Closure of the intakes may be secured by the insertion in each section of 2 steel gates fitted with rubber seals. Protection from drift is provided by trash racks made up of steel bars spaced on 12-in. centers and so arranged that electric heating may be used if required to combat ice. In addition to this a concrete curtain wall is placed upstream from the racks extending some 8 ft below minimum headwater level, serving effectively to fend off floating logs and ice.

The flow of water through the wheels is regulated by welded steel wicket gates 9 ft high and controlled by oil pressure governors whose flyballs are gear driven from the turbine shaft. As is usual with



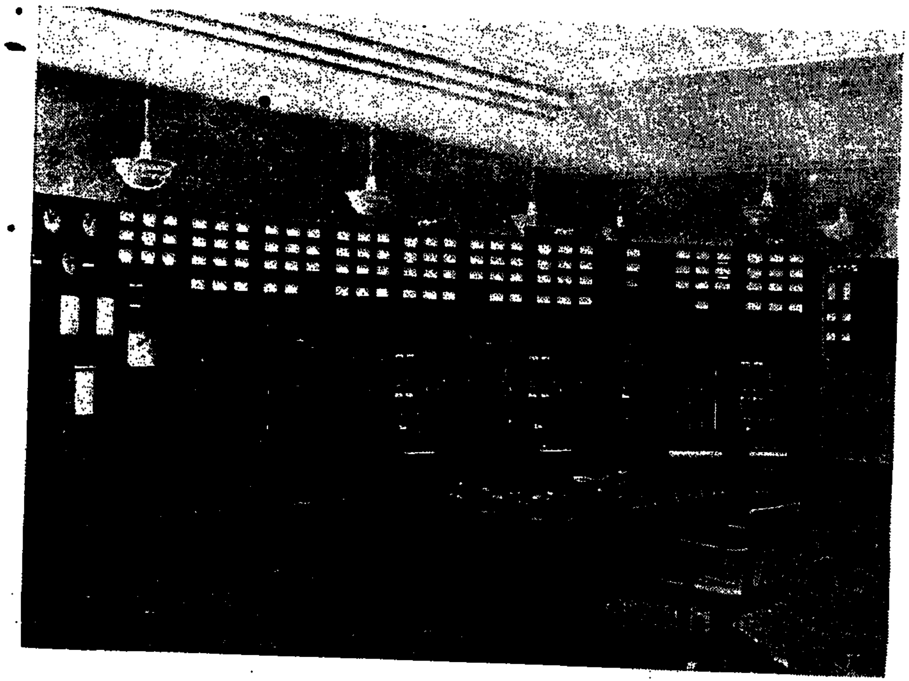
**Various cross-sections through the Rock Island dam—see also front cover of this issue**

this type of turbine, the wheels are set below normal tailwater and for access to a wheel it is necessary that the draft tube be closed as well as the headgates. Steel stoplogs are provided for insertion at the discharge from the draft tube and, with headgates and stoplogs in place, 2 vertical pumps each of 5,000-gpm capacity are used for unwatering the scroll case and draft tube. The draft tubes are of modified elbow design.

## Electrical Equipment

The generators are of the umbrella type each with combined guide and thrust bearing below the rotor; each is rated 16,667 kva, 13.7 kv, 0.90 power factor, 60 cycles. Each stator has an over-all diameter of 28 ft 8 in. A closed recirculating type of ventilating system equipped with air coolers of the surface type is provided for each main generator. Welded steel construction is used throughout and the rotor is of especially rugged construction to withstand the runaway speed of 230 per cent of normal. Excitation is provided by 250-volt main and pilot exciters mounted on the top of each generator shaft, and voltage control is secured by automatic rheostatic voltage regulators on each unit. The neutral of each generator is connected through an oil circuit breaker to a bus which is grounded through a resistor.

Each group of 2 generators is connected through their respective oil circuit breakers to a 13.8-kv bus from which power is fed through a transformer bank to a 110-kv transmission line. Each bank of 3 single-phase transformers has a rating of 30,000 kva with self-cooled operation, and 45,000 kva with forced air cooling. High-speed solenoid-operated oil circuit breakers are installed between the generators and the bus and between the bus and the transformer. A 13.8-kv transfer bus provides a means of erconnecting the stub buses, should operating itions require it. All bus work including the transformer deltas are of copper bars and are housed in indoor concrete cells. Each of the 2 main transformer banks is connected to an outgoing 110-kv line through a motor-operated disconnecting switch which is controlled from the switchboard and interlocked with the oil circuit breaker on the low voltage side to prevent the disconnecting switch from being used to interrupt power. All generators, buses, and transformers have individual differential protection, but no overload. Directional ground, and impedance relays open the 13.8-kv circuit breakers on the transformers in case of trouble on the transmission lines.



The Rock Island control board uses steel panels both front and rear. Indicating meters and control switches are mounted on the front panels; recording meters and relays on the rear panels

The control board is shown in one of the accompanying illustrations. Individual panels are assigned to each generator and to each transformer; 2 panels are used for graphic frequency meters, totalizing meters, voltmeters, and special instruments. Control board wiring is carried on brackets along the edge of each panel and brought down to terminal blocks in a special box in the room directly below the board. Except where walls and mass concrete prevent, wiring is in exposed conduit, and a special room is provided below the electric bay for conduit racks.

Because of the importance of auxiliary equipment in a station of this size, two sources of station power are provided. A 1,760-kva 460-volt vertical generator driven by a propeller waterwheel rated at 2,100 hp at 32-ft head is the primary supply; a 1,760-kva 3-phase transformer provides a secondary supply from the 13.8-kv transfer bus. The 460-volt bus is sectionalized with automatic air circuit breakers to isolate any section that might be in trouble. All important auxiliaries are served by duplicate feeders energized from different sections and equipped with automatic throw-over switches.

## General Information

For the handling of the heavy generating equipment, 2 80-ton cranes are installed in the generator room, each having also a 15-ton auxiliary hoist. Special lifting devices are used on the larger parts to reduce the headroom required for their handling. An 80-ton gantry crane with automatic blocks is used for operation of the crest gates and the head gates. Another 20-ton gantry is provided on the tailrace deck for setting the draft tube stoplogs. A 75-ton transfer crane which traverses the building is used for handling material to and from the tailrace deck, and also for the transfer of materials and equipment from standard cars on the deck through a hatchway in the ceiling of the generator room to the floor below.

To give an idea of the size of the project and the quantities involved, the following few figures are quoted:

| | |
|---|---|
| Reservoir area | 3,000 acres |
| Total estimated excavation | 335,000 cu yd |
| Total estimated concrete | 235,000 cu yd |
| Total ultimate length of power house | 886 ft |
| Total length of dam and abutments | 3,500 ft |

The initial development when completed will make available in an average water-year about 480,000,000 kwhr, whereas the ultimate installation is expected to produce about 1,220,000,000 kwhr annually. This latter figure is equivalent to running the contemplated 150,000-kw capacity continuously at full load for 93 per cent of the time.

In addition to the more usual exploration and test borings on the dam site, and observations and measurements of stream flow, a laboratory model of the entire dam site was made in order to check the flow condition and the discharge capacities of the proposed structures. This model represented a 6,000-ft stretch of river 3,000 ft wide and was made on a scale of 100 to 1. Upon this were built models of the proposed dam and power house, and water in the proper amount was allowed to flow through these structures to give an index of the correctness of design. Cofferdams also were included in the model experiment in order to determine in advance the required height of the necessary cofferdam for both channels of the river under the various flow conditions that were to be expected during the construction period. Observed water levels at the dam site resulting from construction of the actual cofferdam agreed closely with the advance expectations based upon the laboratory model experiment.

# Abstracts

## Of Papers to Be Presented at the Baltimore District Meeting

INTERPRETIVE abstracts of all papers which at the time of this issue are definitely scheduled for presentation at the A.I.E.E. Baltimore District meeting (Oct. 10–13, 1932) are published herewith. In response to popular demand and within its space limitations ELECTRICAL ENGINEERING subsequently may publish certain of these papers, or technical articles based upon them.

Members vitally interested and wishing to obtain a pamphlet copy of any paper available in that form may do so by writing to the A.I.E.E. Order Dept., 33 West 39th Street, New York, N. Y., stating title, author, and publication number of each paper desired.

## 115-Kv Submarine Cable Crossing of the Columbia River

By
E. F. Pearson[1]
G. B. Shanklin[2]
W. R. Bullard[3]
S. B. Clark[1]

THE FIRST submarine installation of oil filled cables in this country has been made. It is a 115-kv cable crossing the Columbia River just north of the city limits of Portland, Ore. The selection of a nominal transmission voltage of 110 kv was determined by an economic analysis based on various schemes of delivering energy to load centers in the Portland area. Conditions were found favorable for laying the cable directly on the bed of the river without the digging of a trench. Three cables were laid 4 ft apart, and the shore ends above extreme low water were trenched in and covered with 4 ft of sand. Oil filled cable was found to possess many advantages for this particular service and therefore was specified instead of cable with solid insulation.

The present paper, in addition to giving the reasons underlying the principal decisions regarding the cable, includes a section on the design and manufacture of the cable and accessories, a description of the design of features incorporated in the field installation, and the procedure followed in making the actual installation. Many unusual construction problems were encountered but by careful planning were solved successfully and operation of the cable under normal conditions since June 19, 1932, has been very satisfactory. Cable temperatures and oil level fluctuations have followed very closely the values calculated for varying load conditions. (A.I.E.E. paper No. 32-125)

## Thermal Transients and Oil Demands in Cables

By
K. W. Miller[4]
F. O. Wollaston[5]

SINCE underground power cables almost always operate under variable loading, it is desirable to establish their allowable carrying capacities on the basis of variable loading rather than upon the basis of some equivalent steady state loading, as is the present practise. For this purpose it is most useful to know what temperature variations will occur at any point in the cable at any time due to an abrupt change from one constant load to another. Then any load curve can be handled with sufficient accuracy by breaking it up into a series of rectangular steps, and adding with proper time intervals the successive thermal transients.

The fundamental equations were developed several years ago, but the numerical solution was too complicated and laborious to be of general practical value. A simplified method is presented in this paper, which employs calculating charts and other devices permitting exact and complete solutions to be obtained and verified in one day, in contrast to approximately one week as required by the former methods. The theory has been verified by measurements on actual cables of the ordinary and oil filled type. In addition to solutions for temperature transients due to abrupt load changes, precise simplified solutions for the following related phenomena are given:

1. Oil demands due to abrupt load changes in oil filled cables.
2. Temperature transients and oil demands due to load variations of any kind, whether abrupt or otherwise.

Although the methods described in this paper were developed for problems of single-conductor cables, they can be applied also directly to 3-conductor cables, using a per phase basis. For oil filled 3-conductor shielded cable with round conductors, the accuracy will be excellent. If the conductors are sector shaped, good accuracy may be obtained by using the equivalent round conductors. For ordinary

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[1] Northwestern Electric Company, Portland, Ore.
[2] General Electric Company, Schenectady, N. Y.
[3] Electric Bond and Share Company, New York, N. Y.

[4] Utilities Research Commission, Chicago, Ill.
[5] Commonwealth Edison Company, Chicago, Ill.

3-conductor cable with solid fillers and no shielding, the accuracy will be only fair.

The duct temperature transient is of importance in problems of variable loading, but has not been adequately investigated; further work should be done along this line. Some of the constants needed for use in thermal and oil-flow problems of cable insulation are relatively new; many of the values now in use for these constants are based upon only a few scattered observations and further laboratory and field data should be obtained. (A.I.E.E. paper No. 32-127)

## Traveling Wave Voltages in Cables

By
H. G. Brinton[6]
F. H. Buller[2]
W. J. Rudge, Jr.[6]

When a traveling wave on an overhead line reaches a cable, a wave of reduced voltage passes into the cable. This reduction is due to the fact that the surge impedance of a cable is less than that of an overhead line. In a traveling wave the electrostatic energy is equal to the electromagnetic energy, and the constants of a cable are such that the voltage of a traveling wave has a lower ratio to the current than in the case of a wave on an overhead line. After the wave enters the cable there are voltage and current reflections back and forth from each terminal. If the length of the original wave is great enough, there will be several superimposed waves at each point in the cable. The sum of these several waves will be dependent upon the shape of the original wave as well as upon the reflections.

The reflection at the cable terminal depends upon the surge impedances of the cable and of the connected line or apparatus. In this paper, calculated values of voltage are given for a range of cable surge impedance from 20 to 150 ohms, and line impedances of 300 and 500 ohms. The calculations include the case of similar lines connected to each end of the cable, and the case of a line connected to one end of the cable only with a free terminal at the other; this latter arrangement gives the higher voltage. The traveling wave is assumed to enter at the "near" end of the cable and the voltage at the "far" end is calculated, since in general the maximum voltage will be found at that end. Reduction of the wave by cable losses is neglected, as tests have shown the losses to be small in 500-ft and 1,000-ft lengths of cable.

Among the results brought out in this paper are the following:

1. Short wave fronts do not greatly affect the ultimate voltage resulting in the cable.
2. Cable voltage is greater for waves which decrease more slowly with time. This difference is more pronounced for the shorter lengths of cable.
3. A higher surge impedance of the line results in a lower voltage in the cable. This effect is greater with longer cables.
4. Cable voltage varies widely with different cable surge impedances, the voltage decreasing with the impedance.

A practical example is worked out in the paper, and suggestions are made for lightning arresters to limit the high voltage impulses. (A.I.E.E. paper No. 32-118)

## Voltage Regulation of Cables Used for Low Voltage A-C Distribution

By
H. R. Searing[7,8]
E. R. Thomas[7]

Distribution of alternating current at low voltages does not depend primarily upon the selection of a conductor size which is thermally adequate, but depends upon the voltage regulation limits which will be satisfactory for lighting, especially when combined lighting and power loads are carried on the same circuit. Voltage regulation of a-c circuits is a function of the magnitude of the current, the power factor, and the circuit impedance. With currents of lower power factor, the inductance component of the impedance becomes the major parameter affecting the voltage regulation, and for a particular circuit and load, there is an optimum ratio of resistance to reactance. While the resistance per unit length of circuit is variable, depending only upon the physical size of the conductor, the reactance per unit length is almost independent of the physical size of the conductors, and for a single circuit with cables, can be changed only by changes in cable construction.

Thus in order to obtain a certain optimum ratio of resistance to reactance for a circuit, there are in general 3 courses of attack; first, for a given physical size the reactance component may be changed by changing the cable construction (the use of single conductor cable or multi-conductor cable employing either sector or concentric construction); second, by changes in the physical size of the conductor; and third, by paralleling 2 or more circuits.

The relative voltage regulations of the different types of cable are given in curves presented in this paper, and it is shown that the regulation efficiency (that is, the amperes per 1,000 cir mils which will give one per cent voltage regulation per 100 ft on a 3-phase 4-wire 120–208-v circuit) improved with the smaller wire sizes of cable. It is further shown that the concentric type of cable has the greatest efficiency, the sector type the next best efficiency, and the single conductor the poorest efficiency, with the twin circuits of single conductor cable lying between the values for single conductor cable and sector type. These data are adjusted for cost of cable at the factory and installed in the field, and it is shown that of the sizes of cable usually found in practise, 500,000-cir mil concentric construction provides the most economical means for transmitting low tension alternating current where the cable is not required to be worked alive. For cable mains, however, where it is necessary to work on live cables, the use of twin circuit 4/0 single-conductor cables is the most economical. Various phase relations between the several conductors are discussed. Test results indicate close agreement with the calculated values. (A.I.E.E. paper No. 32-119)

## Pulp Insulation for Telephone Cables

By
H. G. Walker[11]
L. S. Ford[12]

Pulp insulation is a new type of insulation that has been developed to replace the well known spirally wrapped ribbon paper insulation in certain kinds of telephone cables. It consists of a continuous pulp sleeving formed directly on the wire by a modified paper making process. The raw material for this insulation is commercial Kraft pulp and its preparatory treatment in the beaters corresponds to that given in the regular paper making process.

The machine used to apply this pulp to the wire is a modified single cylinder paper machine equipped to insulate 60 wires simultaneously. The wires are taken from the supply spools by means of flyers so as to allow the brazing of the wire from a nearly empty spool to the wire on a conveniently located full spool. This gives continuous operation. The wires are fed to the machine through an electrolytic cleaner for the removal of residual drawing compound. The surface of the mold or paper forming mechanism is divided into 60 narrow portions in such a way as to form that many narrow sheets continuously. The wires are brought into contact with the mold in such a way that as it rotates and forms the sheets, a single wire is embedded in each sheet. These sheets and wires are transferred from the mold to a traveling wool blanket by the pressure of the couch roll. The traveling blanket carries the sheets and wires through the presses for dewatering and consolidating, and delivers them to the polishers where the sheet is turned down by a rapidly rotating mechanism into a cylindrical wet sleeve surrounding the wire. The moisture is driven from the wet insulation by passage through a box type electric furnace one end of which is maintained at a rather high temperature. The insulated wire then is taken up on spools ready for the twisting operation. The speed of the machine is about 130 ft per min.

The major difficulties in the process have been overcome and the basic properties of the insulation have been determined. Equipment for the production of about 225,000,000 conductor feet per week has been provided and the entire output of 24 and 26 A.W.G. cables is being made in pulp.

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[6] General Electric Company, Pittsfield, Mass.
[7] The United Electric Light & Power Company, New York, N. Y.
[8] New York Edison Company, New York, N. Y.
[9] Western Electric Company, Inc., Baltimore, Md.
[10] The Chesapeake and Potomac Telephone Co. of Baltimore City, Md.
[11] Western Electric Company, Inc., Kearney, N. J.
[12] Bell Telephone Laboratories, Inc., Kearney, N. J.

These cables are designed to the same size as the ribbon paper cables which they replace and compare favorably with them in their electrical characteristics except that the mutual capacitance is slightly higher. The impairment in transmission efficiency due to the higher capacitance is more than offset, however, by the lower first cost of the cable.

Standardized installation practises are followed except that a boiling-out compound softer and more lubricating than paraffin wax, is required, particularly at low temperatures. A suitable compound has been found by adding paraffin oil to wax in varying proportions depending upon the temperature at the point of splicing. The anticipated savings have been realized in the operation of the commercial units and the further expansion of the uses of this insulation is being studied. (A.I.E.E. paper No. 32-122)

## Some Phases of Electrical Testing in a Rubber Covered Wire Plant

By
C. W. Protzman[9]
W. M. Hill[9]

DEVELOPMENT of new machines and processes for the manufacture of rubber covered wire made possible "straight line" production methods, with the elimination of process stocks and storage. However, the advantages of this method of production were reduced by the fact that the standard water test applied to the finished wire did not lend itself to this method of production.

With this process a stock of wire must be kept in the test tanks for a minimum 12-hr period, and stored in racks for an additional drying period. This requires stocks of process material, and in addition, the water test equipment requires a relatively large area; also separate equipment is necessary for coiling the tested wire.

A combined testing and coiling machine therefore was developed which wound the wire in coils ready for shipment and simultaneously furnished an electrical insulation test of the dry or "spark" type. The "spark" test involves the impression of a relatively high a-c voltage upon the insulation of the wire under test, with its conductor grounded. The entrance of a defect into this high voltage zone permits a flashover which actuates control apparatus to give an audible and visual signal and to stop the passage of the wire.

The circuit consists fundamentally of a specially built low power transformer with a condenser in the high voltage circuit to boost the commercial frequency to several hundred cycles when this circuit is closed suddenly. The signal and control apparatus is connected in the low voltage circuit. The voltage is impressed on the wire by means of an electrode approximately 5 ft long through which the wire passes, and the defect is located accurately for patching or removal by means of a small fault locator or electrode which is placed beyond the testing electrode.

Results of comparative checks on a large quantity of wire over an extended period indicated that the "spark" test performed more consistently than did the comparable water test. It is apparent that wider application of this method may be made by the entire rubber covered wire industry. (A.I.E.E. paper No. 32-120)

## Use of Cables for Telephone Distribution Purposes

By
M. C. Rose[10]
H. A. Russell[10]

TELEPHONE CABLES containing large groups of insulated conductors in a common sheath have been developed rapidly since 1882; previous to that time all telephone distribution was by means of overhead wire plant. The present maximum sized cables in use contain 1,818 pairs of 26-gage conductors in a sheath having an outside diameter of $2^5/_7$ in. The increase in the amount of cable in plant during the past decade in certain metropolitan areas, such as Baltimore, Md., and Washington, D. C., has been over 100 per cent, and at the present time the value of the cable plant represents about 25 per cent of the total plant investment in these areas.

The type of cable distribution whether underground, aerial, attached to building walls, or located in buildings, depends generally upon the character of the area to be served and the station density. A complete system of records continuously maintained is an essential in the design of the distributing plant. The more important features of economical design include the gage requirements for transmission, the provision of facilities to care for existing business, and sufficient spare at the proper locations to care for reasonable expectations of growth.

The uses of telephone cable for distribution purposes in typical metropolitan areas, such as Baltimore and Washington, is outlined in this paper, including some historical background as to the development of cable and the part it takes in the present over-all plant investment. The division of metropolitan areas into central office areas and the various types of distribution are discussed. The engineering procedure followed in the design of cable distributing plant to provide economically a metallic cable circuit of satisfactory transmission quality for each subscriber's line to connect with the central office, involves the consideration of many factors. (A.I.E.E. paper No. 32-121)

## Safe Harbor Project

By
N. B. Higgins[13]

DELIVERY of power to Baltimore, Md., from the first unit of the Safe Harbor hydroelectric plant on the Susquehanna River, began December 7, 1931, 20 months and 7 days after active work was started on the project site—an outstanding achievement in the annals of hydroelectric construction. The drought that prevailed during the construction period and the absence of high floods were important contributary factors to the speed with which the work was executed. In an average year, the Safe Harbor plant will generate over 800,000,000 kwhr, resulting in an annual coal saving in excess of 500,000 tons.

In the lower Susquehanna basin between Columbia, Pa., and the Chesapeake Bay, there is a difference of elevation of about 227 ft. The initial development, now known as the Holtwood project, went into operation in 1910, and left available for future development a fall of about 100 ft below and 57 ft above Holtwood. The lower development, commonly known as the Conowingo project, was constructed and went into operation in 1928. The development of the head between Holtwood pool and Columbia, known as the Safe Harbor project, is the subject of this paper.

The various features in connection with this project are discussed in detail. These include the reservoir conditions, hydraulic structures, forebay, power house, and electrical features. A major problem in electrical design at Safe Harbor has been to provide a flexible layout which will permit the installation as required of equipment for generation, transformation, and transmission at 60 cycles 3-phase, and 25 cycles single-phase. The plant is of the most modern design throughout, incorporating many novel features. (A.I.E.E. paper No. 32-123)

## Safe Harbor-Westport 230-Kv Transmission Line

By
E. Hansson[13]

SAFE HARBOR development will have an ultimate capacity of 510,000 hp, a large portion of which will be available for Baltimore. During certain periods Baltimore will be dependent primarily upon this Safe Harbor power; therefore, reliability of transmission is of the utmost importance. The selection of the operating voltage was made only after a thorough investigation of the relative economic and reliability factors involved, the possibility of future interconnections, and system stability. Studies made in conjunction with the engineers of the Consolidated Gas Electric Light and Power Company of Baltimore covered a comparison of 2 23-kv circuits with 6 110-kv circuits. These studies also included investigation of such problems as terminal location, 2-point versus single-point supply, the use or omission of high voltage buses, and amount of synchronous condenser capacity required. An a-c calculating board was employed to check the results obtained by analytical methods.

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[13] Pennsylvania Water & Power Company, Baltimore, Md.

The decision was made finally in favor of the higher voltage as offering lower cost, greater reliability, and greater possibilities for interconnection. Voltage regulation on the city network and control of short-circuit currents made power delivery to each side of the city advisable.

A brief description of the design of the Safe Harbor 230-kv transmission lines is presented in this paper. Attention is called to the separate routes of the 2 lines connecting the generating plant with the load center at Baltimore. The lines are the most heavily insulated so far constructed, and the ground wire protection has been applied according to the latest theory. Special effort has been made to reduce tower to ground resistances. Conductor tension has been kept low and armor rods are used at all suspension joints to guard against vibration troubles. The type of concrete anchors used lessens construction costs and facilitates erection of towers.

After comparing various designs, a 795,000-cir-mil A.C.S.R. conductor was chosen. Much has been said about the frailty of A.C.S.R. and about the precautions needed to protect it against damage. The Safe Harbor line was strung without any special safeguards, yet it stands completed with only 3 repair sleeves, and 2 of those could have been left off. (A.I.E.E paper No. 32M16)

## Reception and Distribution of Safe Harbor Energy in Baltimore

By
A. S. Loizeaux[15]

ENERGY from the Safe Harbor development was first received in Baltimore during December 1931, and at once took an important place in the energy supply of this city. Baltimore has both 25-cycle and 60-cycle loads, the maximum 25-cycle load recorded being 125,400 kw, the maximum 60-cycle load being 104,800 kw, and maximum simultaneous load on both frequencies being 188,200 kw. The 25-cycle frequency was originally chosen for industrial purposes and for the operation of rotary converters, although in recent years growth on this frequency has been held back. Shortly after completion of the Safe Harbor-Westport transmission line the frequency at Baltimore was changed from the former value of $62^1/_2$ cycles to 60 cycles, and the older frequency changers were shut down. One 30,000-kw frequency changer at Westport now takes care of all energy interchanged between these 2 systems. The characteristics and control of this frequency changer are described in the paper.

A bank of surge proof transformers of 126,000-kva capacity step down the Safe Harbor energy from 230 kv to 33 kv in a new outdoor substation. This 33-kv system ties into the 2 principal steam generating stations in Baltimore, and through them to the transmission system, chiefly of 13 kv, extending to Baltimore substations and surrounding territory. The main features of these transmission systems are described in the paper. (A.I.E.E. paper No. 32-126)

## Low Head Hydroelectric Developments

By
A. V. Karpov[14]

THE DESIGN of an up to date low head hydroelectric power plant requires a thorough understanding of the ideas and theories that have originated within the past few years in connection with such developments. The present paper is an attempt to review the latest work and to show some of the changes that have been made in the design of low head plants.

In the eastern part of the United States, and to a greater extent in Europe, power sites that could be developed economically by the use of conservative Francis-type turbine are diminishing rapidly. Many of the remaining low head sites can be developed only by the use of more economical methods; that is, by turbines of the propeller and, particularly, the Kaplan type. Kaplan turbines have been in commercial use only for the past few years, the units at the Safe Harbor plant being among the largest of this type. It is stated that the development of this type of turbine was accomplished entirely in Europe.

Various types of low head turbines are discussed in this paper, including the various theoretical and practical considerations which must be given each installation. Comparisons of European and American designs are given and future trends are indicated. It is stated that the runner blades and, in general, all parts of the runner which come in contact with flowing water in the Kaplan units at the Ryburg-Schworstadt plant, Germany, are machined and polished. In contrast to this the steel castings smoothed only by hand or by emory wheels at Safe Harbor probably represent a lack of proper machining equipment in the United States. The low setting of the center line of the runner at Safe Harbor, that is, 6 ft below normal tail-water elevation, probably is due partly to this deficiency. The paper indicates future trends in design. (A.I.E.E. paper No. 32M15)

## Safe Harbor Kaplan Turbines

By
L. M. Davis[16]
G. W. Spaulding[16]

ONE of the numerous features of more than usual interest at the Safe Harbor hydroelectric development is the application of the Kaplan type of automatically adjustable blade propeller turbine. This type of turbine is used in all 6 units of the initial installation, each unit rated at 42,500 hp under a rated head of 55 ft. Safe Harbor is the first installation in America of Kaplan type turbines of large capacity, although they have been used for low head developments in Europe since 1919.

Many new and interesting problems arose in connection with these Safe Harbor turbines requiring, as with any pioneering development of this magnitude, an unusual amount of experimental and engineering study involving not only the hydraulic and mechanical design of the plant but affecting the structural and electrical design as well. The absence on this continent of a hydraulic testing laboratory in which cavitation tests could be made resulted in the construction of such a laboratory at Holtwood, Pa., adjacent to the Holtwood hydroelectric plant.

In addition to describing the laboratory at Holtwood and the tests carried out there, the paper includes the reasons for installing Kaplan units at Safe Harbor, together with a description of these units. In the laboratory, particular attention was given to cavitation, the phenomena resulting when a vacuum is formed under the runner blade. Tests on a complete model of the Safe Harbor intake, scroll case, wheel setting, runner, and draft tube, were made to determine within very close limits the highest elevation at which the runner could be set without danger of serious cavitation, for the maximum turbine power desired.

After deciding upon the general design of tube, further studies were carried out along 3 lines: First, the determination of the most economical length of the horizontal section of the tube; second, the determination of the maximum upward turn of this horizontal leg which could be considered without sacrificing efficiency; and third, the determination of the proper area at the discharge end of the tube.

The test program has resulted in numerous improvements in operating performance, and savings in construction costs. Engineers of the 2 turbine manufacturers cooperated in jointly developing and manufacturing turbines of identical design wherein practically all replaceable parts are interchangeable.

The first 6 months of actual performance indicate that the prediction of the cavitation limits is reasonably close, although a considerably longer period will be necessary definitely to establish a close correlation between laboratory and field results. (A.I.E.E. paper No. 32-124)

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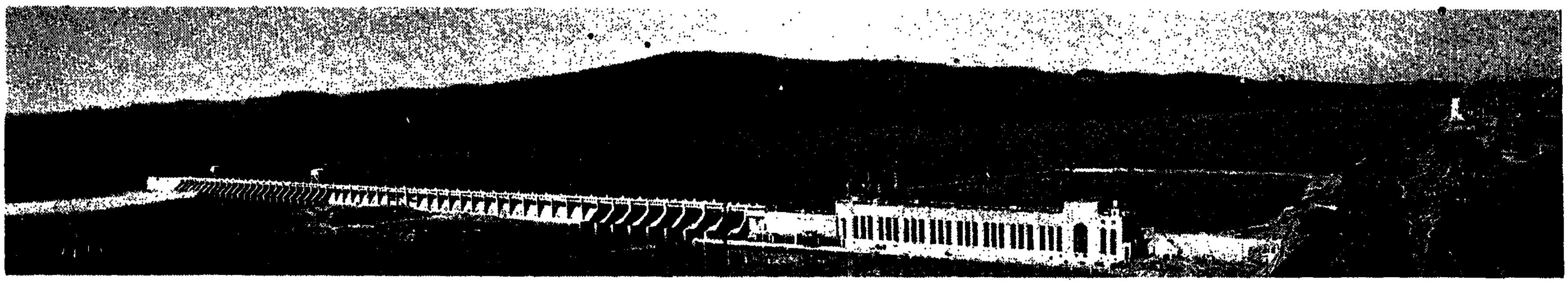
[14] Aluminum Company of America, Pittsburgh, Pa.

[15] Consolidated Gas, Electric Light and Power Company of Baltimore, Md.

[16] Safe Harbor Water Power Corporation, Baltimore, Md.

# News
## Of Institute and Related Activities



Safe Harbor development on the Susquehanna River. This plant of the Safe Harbor Water Power Corporation will be visited during the coming Middle Eastern District meeting of the Institute in Baltimore, Md., October 10–13, 1932, and is the subject of several interesting papers to be presented. Six Kaplan type turbines, each rated 42,500 hp under a head of 55 ft, are installed in this plant and are the first large Kaplan type units to be installed in this country

# Baltimore Meeting Program Includes Interesting Features

CABLES both for power and for telephone use, and hydroelectric developments with particular reference to the Safe Harbor plant of the Safe Harbor Water Power Corporation on the Susquehanna River, are the outstanding features of the technical program arranged for the Institute's Middle Eastern District meeting to be held in Baltimore, Md., October 10–13, 1932, with headquarters in the Lord Baltimore Hotel. Inspection trips and entertainment features round out the program and assure a worth while meeting in this most interesting city.

### TECHNICAL SESSIONS

Four technical sessions will be held during the meeting. The first session is under the joint auspices of the A.I.E.E. and the National Research Council, with Dr. J. B. Whitehead presiding; it will deal with timely cable problems, namely, economics, thermal transients, and traveling wave voltages. Also, the paper describing the Columbia River 115-kv oil filled submarine cable installation is of particularly noteworthy interest.

The second session will present a group of papers on design, fabrication, test, and use of telephone cables, and should prove of wide interest. The third and fourth sessions will treat waterpower development with particular reference to the Safe Harbor plant, including transmission and utilization of the energy; they will also describe the research activities at the Holtwood hydraulic laboratory that culminated in the design of the turbine at Safe Harbor for operation at high efficiency under partial load and with variable head. The generating units at Safe Harbor, each rated at 42,500 hp, represent the first installation of Kaplan type turbines of large capacity in America.

The National Research Council committee on electrical insulation has arranged an informal session at which results of recent research in the field of dielectrics and insulation will be discussed.

### INSPECTION TRIPS

Among the inspection trips which have been arranged to various manufacturing plants, are those to the Bethlehem Steel Company's mills at Sparrows Point, the refinery and wire mill of the American Smelting and Refining Company, and the telephone cable plant of the Western Electric Company. A trip also will be made to the works and high voltage laboratory of the Locke Insulator Company where there will be a special demonstration involving 3,000-kv lightning impulses, and 1,000-kv 60-cycle waves. A special excursion will be made to the Safe Harbor hydroelectric plant where the Kaplan turbines, step-up substation, 230-kv river crossing, and other interesting details may be inspected.

### OTHER FEATURES

Baltimore has so much of general and historic interest to offer visitors that a sightseeing and entertainment program of unusual interest will be provided, including for the women a trip to Annapolis, the 300-yr old capital of Maryland which still retains much of the charm of Colonial days. Golf and tennis features also have been arranged in abundance. Full details of the entertainment features planned for the meeting will be given in the program folder now being prepared. Hotel registration cards will accompany this folder.

A meeting of the board of directors will be held on October 13, 1932, in connection with this meeting.

### COMMITTEES

The committees handling the various phases of the work in connection with the Baltimore District meeting are as follows:

**District Meeting**—W. B. Kouwenhoven, *chairman*, vice-president, Middle Eastern Dist.; G. S. Diehl, *secretary;* A. F. Bang, F. A. Connor, K. A. Hawley, C. N. Johnson, L. G. Smith, J. T. Walther, and G. L. Weller.

**General**—K. A. Hawley, *chairman;* J. Wells, *secretary;* J. R. Baker, A. F. Bang, G. S. Diehl, R. C. Faught, A. Hughes, W. B. Kouwenhoven, W. O. Peale, A. L. Penniman, Jr., and L. G. Smith.

**Papers**—A. F. Bang, *chairman;* J. R. Baker, W. B. Kouwenhoven, J. L. D. Speer, and J. B. Whitehead.

**Hotel and Registration**—L. G. Smith, *chairman;* J. M. Barry, C. A. Brunner, F. Hamburger, and J. L. Hildebrandt.

**Banquet and Entertainment**—W. O. Peale, *chairman;* G. S. Diehl, R. C. Faught, C. S. Fiske, D. G. Howard, R. H. Lang, A. J. Pates, and C. V. O. Terwilliger.

**Transportation and Inspection**—Adrian Hughes, *chairman;* E. W. Jahn, G. R. Page, A. Rusk, and I. B. Yeakle.

**Printing and Publicity**—A. L. Penniman, Jr., *chairman;* J. H. Davis, A. Hughes, R. L. McCoy, and J. Wells.

**Golf**—F. E. Ricketts, *chairman;* G. H. Gilbert and C. V. Woodward.

**Finance**—W. H. Meese, *chairman;* F. A. Allner, C. M. Cohn, J. H. Davis, and F. J. Irish.

**Ladies**—Mrs. J. B. Whitehead, *chairman;* Mrs. F. A. Allner, Mrs. D. G. Howard, Mrs. W. B. Kouwenhoven, Mrs. L. G. Smith, Mrs. C. V. O. Terwilliger, Mrs. R. L. Thomas, and Mrs. John Wells.

## Program

All technical sessions will be held in the Lord Baltimore Hotel and are scheduled on eastern standard time. Abstracts of all papers which at the time of this issue were definitely scheduled for presentation at the Baltimore District meeting are presented in this issue of ELECTRICAL ENGINEERING, p. 659–62.

### Monday, October 10

**9:00 a.m.—Registration**

**2:00 p.m.—Cables—A Joint Session of the A.I.E.E. and the National Research Council, Dr. J. B. Whitehead, *presiding***

THE COLUMBIA RIVER 115-KV OIL FILLED SUBMARINE CABLE, E. F. Pearson, Northwestern Electric Co., G. B. Shanklin, General Electric Co., W. R. Bullard, Electric Bond and Share Co., and S. B. Clark, Northwestern Electric Co.

THERMAL TRANSIENTS AND OIL DEMANDS IN CABLES, K. W. Miller, Utilities Research Commission and F. O. Wollaston, Commonwealth Edison Co.

VOLTAGE REGULATION OF CABLES USED FOR LOW VOLTAGE A-C DISTRIBUTION, H. R. Searing, The United Electric Light and Power Co. and The New York Edison Co., and E. R. Thomas, The United Electric Light and Power Co.

TRAVELING WAVE VOLTAGES IN CABLES, H. G. Brinton, F. H. Buller, and W. J. Rudge, Jr., General Electric Co.

### Tuesday, October 11

**9:30 a.m.—Telephone Cables—J. L. Dawson Speer, *presiding***

SOME PHASES OF ELECTRICAL TESTING IN A NEW RUBBER COVERED WIRE PLANT, C. W. Protzman and W. M. Hill, Western Electric Co., Inc.

PULP INSULATION FOR TELEPHONE CABLES, H. G. Walker, Western Electric Co., Inc., and L. S. Ford, Bell Telephone Laboratories, Inc.

USE OF CABLES FOR TELEPHONE DISTRIBUTION PURPOSES, M. C. Rose and H. A. Russell, The Chesapeake and Potomac Telephone Company of Baltimore City.

**Tuesday Afternoon**

A session of the committee on electrical insulation of the National Research Council, Dr. J. B. Whitehead, *chairman*, to be held at the school of engineering of The Johns Hopkins University. In this session the results of recent research in the field of dielectrics and insulation will be presented. Informal reports of progress will be presented by manufacturers, scientific societies, and governmental and university laboratories.

### Wednesday, October 12

**9:30 a.m.—Safe Harbor Development—A. F. Bang, *presiding***

*ECONOMIC ASPECTS OF WATER POWER, F. A. Allner, Pennsylvania Water and Power Co.

SAFE HARBOR PROJECT, N. B. Higgins, Pennsylvania Water and Power Co.

SAFE HARBOR-WESTPORT 230-KV TRANSMISSION LINE, E. Hansson, Pennsylvania Water and Power Co.

RECEPTION AND DISTRIBUTION OF SAFE HARBOR ENERGY IN BALTIMORE, A. S. Loizeaux, Consolidated Gas, Electric Light, and Power Company of Baltimore.

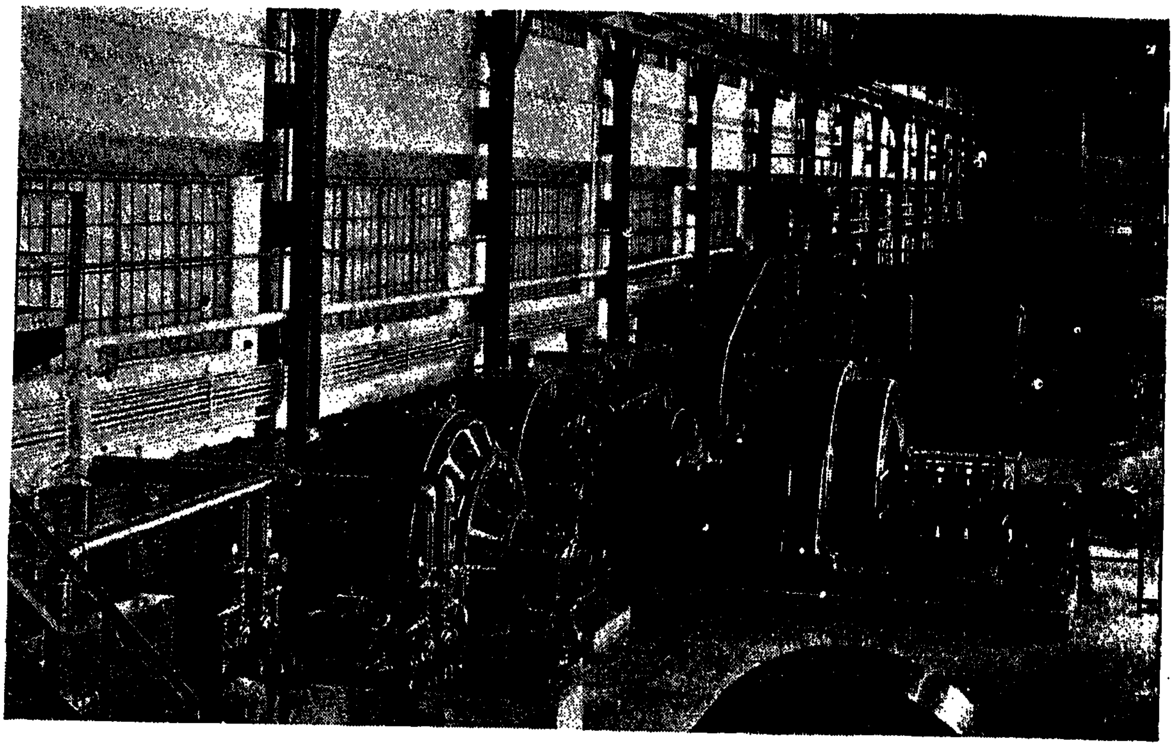
**2:00 p.m.—Safe Harbor Development—J. R. Baker, *presiding***

LOW HEAD HYDROELECTRIC DEVELOPMENTS, A. V. Karpov, Aluminum Company of America.

SAFE HARBOR KAPLAN TURBINES—DESIGN OF SETTING AND CAVITATION LIMIT AS DEVELOPED AT THE HOLTWOOD HYDRAULIC LABORATORY, L. M. Davis and G. W. Spaulding, Safe Harbor Water Power Corp.

**Wednesday Afternoon**

The meeting of the National Research Council, committee on electrical insulation, will be continued at the engineering school of The Johns Hopkins University.



**The Sparrows Point, Md., plant of the Bethlehem Steel Company may be inspected by those attending the coming Middle Eastern District meeting of the Institute, October 10–13, 1932. Above is shown a general view of the motor room of the 27- 24- 21-in. continuous skelp and sheet bar mill in the Sparrows Point plant**

### Thursday, October 13

Excursion to the Safe Harbor Plant

Note: Arrangements will be made for those desiring to return home promptly to connect with through trains at junction points.

### RULES ON PRESENTING AND DISCUSSING PAPERS

At the technical sessions papers will be presented in abstract, 10 minutes being allowed for each paper unless otherwise arranged, or the presiding officer meets with the authors preceding the session to arrange the order of presentation and allotment of time for papers and discussion.

Any member is free to discuss any paper when the meeting is thrown open for general discussion. Usually 5 minutes are allowed each discusser. When a member signifies a desire to discuss papers on other subjects or groups, he shall be permitted a 5-min. period for each subject or group.

It is preferable that a member who wishes to discuss a paper give his name beforehand to the presiding officer of the session at which the paper is to be presented. Copies of discussion prepared in advance should be left with the presiding officer. Each discusser is to step to the front of the room and announce, so that all may hear, his name and professional affiliations. Discussions at the technical sessions are not reported. To be considered for publication, discussions should be written and mailed to the A.I.E.E., Editorial Department, 33 West 39th Street, New York, N. Y., on or before Oct. 28, 1932.

**1931 Proceedings of International Conference Published.**—The full proceedings of the 1931 session of the International Conference on Large High Tension Electric Systems, held under the auspices of the International Electrotechnical Commission, has just been published (in French). They are in 3 bound volumes, 2,500 pages with 600 illustrations, are published by the International Conference, Avenue Marceau, 54, Paris, France, and cost 380 fr. Vol. 1 deals with generating and transforming equipment, vol. 2 with transmission lines, and vol. 3 with network operation, protection, and interconnection.

## Pacific Coast Convention Reports

The Pacific Coast convention of the Institute being held at Vancouver, B. C., August 30 to September 2, 1932, cannot, of course, be reported in this issue of ELECTRICAL ENGINEERING, but a general news story covering convention activities is scheduled for the October issue. It is hoped also that written discussion of the Pacific Coast convention papers will be mailed to the A.I.E.E. editorial department, 33 West 39th Street, New York, N. Y., in sufficient time and in sufficient quantity to warrant the presentation of a review of discussion in the October issue; written discussions are due in New York on or before Sept. 16, 1932.

The program of the Pacific Coast convention was announced in ELECTRICAL ENGINEERING for July 1932, p. 518–9, and abstracts of all papers then scheduled for presentation were given in ELECTRICAL ENGINEERING for August 1932, p. 583–6.

**Construction Reports for 1929.**—Census reports of construction figures, compiled from data gathered in the census of distribution for the year 1929, show the construction business of the contractors in various states for that year. These construction reports are now available for a number of states, and are being compiled for remaining states.

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* These papers are under consideration for presentation at the Middle Eastern District meeting, but up to date of going to press have not been officially placed upon the program.

The bulletins are obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., for a nominal cost.

## A.I.E.E. Directors Meet at Institute Headquarters

The regular meeting of the board of directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, N. Y., on Tuesday, August 2, 1932.

Present were: *President*—H. P. Charlesworth, New York, N. Y. *Past-presidents*—W. S. Lee, Charlotte, N. C.; C. E. Skinner, East Pittsburgh, Pa. *Vice-presidents*—K. A. Auty, Chicago, Ill.; W. E. Freeman, Lexington, Ky.; W. B. Kouwenhoven, Baltimore, Md.; E. B. Meyer, Newark, N. J. *Directors*—L. W. Chubb, East Pittsburgh, Pa.; A. B. Cooper, Toronto, Ont.; A. E. Knowlton, New York, N. Y.; G. A. Kositzky, Cleveland, Ohio; A. H. Lovell, Ann Arbor, Mich.; C. E. Stephens, New York, N. Y.; A. C. Stevens, Schenectady, N. Y.; R. H. Tapscott, and H. R. Woodrow, New York, N. Y. *National Treasurer*—W. I. Slichter, New York, N. Y. *Acting National Secretary*—H. H. Henline, New York, N. Y.

The minutes of the directors meeting of June 22, 1932, were approved.

A report of a meeting of the board of examiners held July 27, 1932, was presented and approved. Upon the recommendation of that board, the following actions were taken upon pending applications: one applicant was transferred to the grade of Fellow, 4 applicants were elected to the grade of Member and 19 were transferred to the grade of Member; 31 applicants were elected to the grade of Associate; 11 Students were enrolled.

Announcement was made of the committee appointments made by the president for the administrative year beginning August 1, 1932, and various representatives were appointed by the board. (The list of committees and representatives is given in this issue of ELECTRICAL ENGINEERING, p. 678-681.)

In accordance with the by-laws of the Edison Medal committee, the board confirmed appointments to the committee made by the president, as follows: D. C. Jackson, chairman for the year beginning August 1, 1932; Gano Dunn, S. P. Grace, and C. E. Stephens, for terms of 5 years each. Also, the board elected from its own membership to serve for terms of 2 years each: J. Allen Johnson, A. E. Knowlton, and R. H. Tapscott.

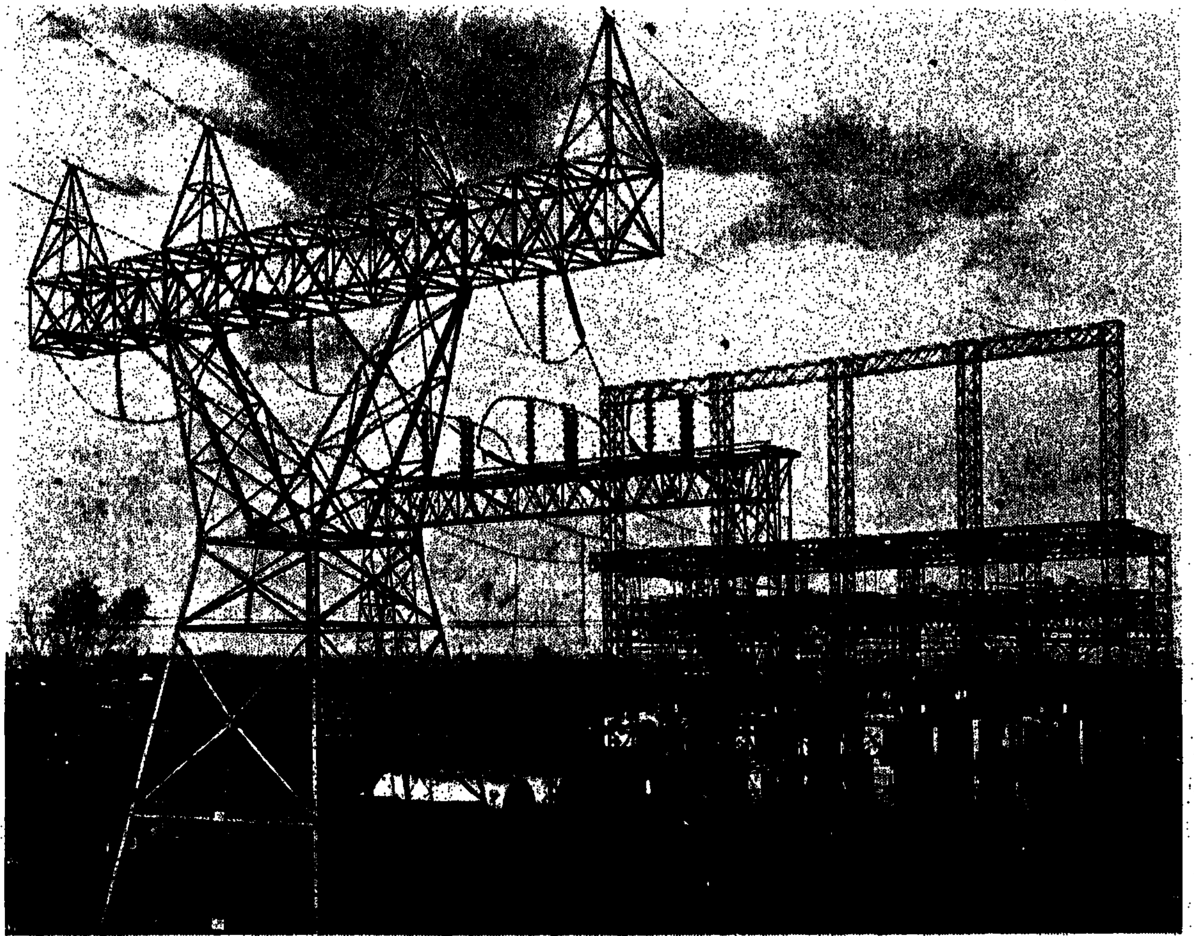
In accordance with the by-laws of the Lamme Medal committee, the board confirmed the following appointments by the president: P. L. Alger, H. B. Gear, and C. E. Skinner, for terms of 3 years each; C. E. Skinner, to serve as chairman for the year beginning August 1, 1932.

Local honorary secretaries were reappointed for the 2-yr term beginning August 1, 1932, as follows: V. J. F. Brain, for Australia; W. Elsdon-Dew, for Transvaal; A. S. Garfield, for France.

Various matters were discussed and referred to appropriate committees for consideration and recommendation.

Decision was made to hold the October meeting of the board of directors in Baltimore, Md., on October 13, 1932, during the Middle Eastern District meeting.

Other matters were discussed, reference to which may be found in this or future issues of ELECTRICAL ENGINEERING.



**Substation at the Baltimore, Md., end of the transmission line from the Safe Harbor plant on the Susquehanna River. Energy is transformed from 230 kv to 33 kv at this substation, and distributed at the latter voltage to other substations located at load centers. This substation may be visited during the Middle Eastern District meeting in Baltimore, Md., October 10–13**

## Engineering Board Appointed for R.F.C.

President Hoover (HM'29) has named the board of engineers which is to pass upon the engineering adequacy of projects for which applications for loans are made to the Reconstruction Finance Corporation. The board of 6 members consists of Charles D. Marx, *chairman;* John F. Coleman, John Lyle Harrington, John H. Gregory, Herbert G. Moulton, and Major-General Lytle Brown. The chairman of the board was selected by the president and the other members were selected from a list submitted by American Engineering Council.

Each major geographical division of the country is represented on the board, and consideration was given the experience of the members along the lines that most of the applications for loans are expected to cover. The chairman, Charles D. Marx, is professor emeritus of civil engineering at Leland Stanford University, Calif., and occupied the chair of civil engineering at that institution from its establishment in 1891 until his retirement in 1923. He has done considerable consulting work and has served as chairman of the state water commission of California. He is an honorary member and past-president of the American Society of Civil Engineers.

John F. Coleman, New Orleans, Ala., has been in consulting engineering practise in that city since 1900, specializing in river and port projects, land reclamation, and railroad and utility valuation. He at one time was principal assistant city engineer of New Orleans, and also is a past-president of the American Society of Civil Engineers.

John Lyle Harrington, Kansas City, Mo., is a member of the consulting engineering firm of Harrington & Cortelyou, Kansas City. Since his graduation from college in 1895, he has been active in bridge work, and for the past 25 years he has carried on a consulting and designing practise. He is a past-president of The American Society of Mechanical Engineers.

John H. Gregory, Baltimore, Md., is a consulting engineer and professor of sanitary engineering at Johns Hopkins University. He has been in sanitary engineering work since his graduation in 1895, first in Boston with the metropolitan sewerage commission and the metropolitan water board, and subsequently in private practise in New York and Baltimore.

Herbert G. Moulton, New York, N. Y., is a consulting engineer specializing in reports for banking interests on railroad and mining operations and finance. During the War he served with the war industries board, and from 1915 to 1920 was advisor to the Public Service Commission of New York on timbering in the New York subways.

Lytle Brown, chief of engineers, U.S. Army since 1929, is an *ex-officio* member of the board. He has had wide experience in government work both in the engineer corps and on the general staff of the Army, and is well known for his unusual executive ability.

## Prominent Civil Engineer Dies

Charles Warren Hunt, who was secretary of the American Society of Civil Engineers from 1895 to 1920, and then upon retirement from active service was elected secretary emeritus of that organization, died on July 23, 1932. He was born in New York, N. Y., in 1858, the son of an eminent lawyer, and in 1876 was graduated from a civil engineering course at New York University. In 1909 his alma mater conferred the honorary degree of doctor of laws upon him.

After a few years in varied engineering positions, Mr. Hunt was appointed assistant secretary and librarian of the A.S.C.E. in 1892, and in 1895 became national secretary of that organization. In this capacity he was untiring in his efforts to promote the good of the engineering profession, and many important accomplishments may be attributed to him.

**Lincoln Arc Welding Prize Award.**—A jury under the direction of Prof. E. E. Dreese (M'25) of Ohio State University, Columbus, awarded the prizes for papers in the second arc welding prize competition sponsored by The Lincoln Electric Company of Cleveland, Ohio. First prize of $7,500 was awarded to Lt.-Com. H. N. Wallin, U.S.N., and Lt. H. A. Schade, U.S.N., jointly for their paper "The Design and Construction of an Arc-Welded Naval Auxiliary Vessel." Second prize of $3,500 was awarded Maj. G. M. Barnes, U.S. Army, for his paper "Manufacture of Ordnance at Watertown Arsenal Revolutionized Through Arc Welding." The third prize of $1,500 was won by H. H. Tracy (A'26), of the Southern California Edison Company, Ltd., Los Angeles; the fourth prize of $750, by G. F. D. Wahl and H. E. Johns, Kiel, Germany; fifth prize of $500, by H. J. L. Bruff, Harrogate, England; and the sixth prize of $250, by W. H. Zorn, Wyandotte, Mich. Thirty-five additional prizes of $100 each were awarded to writers of papers showing the application of and saving possible by arc welding in every industry. Checks for the amounts of the 3 largest prizes were "written" on $^1/_8$ in. sheet steel; all information on the checks was arc welded, a submachine gun being used for cancellation.

## Fast Escalators Move London Subway Crowds

Increasingly heavy traffic in the London, England, subways recently has rendered inadequate the type of escalators previously used. Improvement plans of the London (Underground) Electric Railway Company, Ltd., required an escalator which would be capable not only of vertical rises higher than those possible with the present standard escalator, but also capable of higher speeds to permit a more rapid handling of passengers. This resulted in designing and building a new escalator suitable for a maximum vertical rise of 90 ft., capable of a speed of 180 ft. per min. (twice that of the old escalators), and computed to be capable of handling 16,000 persons per hr (or double the number of the old).

A sample machine first was erected and put into operation in the Otis Elevator Company's works at Harrison, N. J. After the usual tests it was inspected by the engineers of the London (Underground) Electric Railway Company, Ltd., and 51 of these new machines were ordered. They are to be installed at various subway stations in London, and for vertical rises of from 24 to 90 ft.

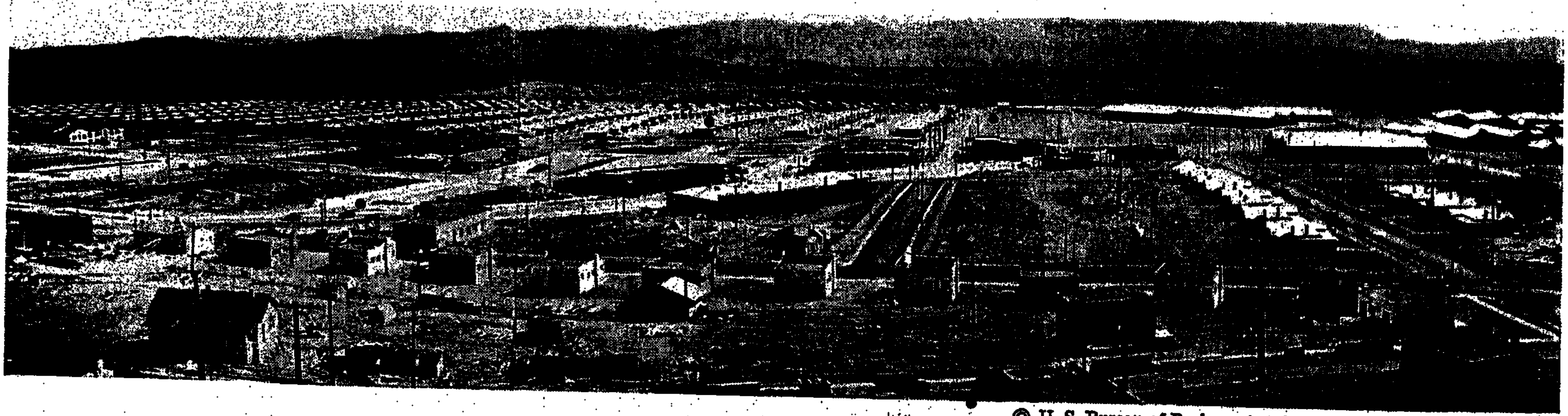
This new escalator already is proving a remarkable success. The public is showing no hesitancy in accommodating itself to the higher step-speed, and of course the quicker transportation is popular.

—From an article appearing in *Electric Traction and Bus Journal* for June 1932, p. 253.

**European Broadcasting Stations.**—Information on broadcasting conditions in European countries has been furnished by A. H. Morton (A'24) European manager of the Radio Corporation of America. He states that while European broadcasting is still several years behind that in America in programs and technique, in the opinion of most observers the European equipment is good and programs are improving. Russia has three stations of 100 kw each; Warsaw, Poland, one of 150 kw; France has one of 100 and one of 80. Scattered through Germany and Italy are 50-kw stations. Broadcasting is still largely under state influence which takes various forms; but in Europe interest in commercially sponsored programs is growing in the countries where it is not forbidden by regulation.

**Salary and Wage Reduction Survey Completed.**—A report which should do much to set at rest the vast amount of speculation as to the extent and severity of salary and wage cuts throughout the country during the present depression has been issued by the National Industrial Conference Board, Inc. The statistics presented are based upon unusually comprehensive and complete returns from 1,718 business concerns of every nature except agricultural, personal, and professional pursuits. Among the large number of significant facts revealed in this analysis is that the smaller business and industrial concerns have made more drastic reduction in salaries and wage scales during the present depression than have the larger concerns. Executive sala-

## Boulder City Emerges From the Status of a Construction Camp to a Complete City



© U. S. Bureau of Reclamation, Department of the Interior

Boulder City, Boulder Canyon project, Nev., organized to take care of the construction forces employed at Hoover Dam, is now the model construction city of the United States, and represents many of our national ideals. Comfortable homes have been built to house the workers and their families, dormitories and dining rooms have been constructed, schools, churches, and clubs completed, streets paved, and landscaping has been carried out on a large scale. A municipal organization has been set up under a city manager to assure adequate government for the population of over 3,000 employed persons and their families. Over 1,000 buildings have been completed, about 90 per cent of these being residences. Six Companies, Inc., owns the majority of these, although over 100 are owned by the government, and an approximately equal number by business permittees.

ries have taken the greatest reduction, with other salaries second, and wage rates the smallest. It also is shown that on the average, the companies making no reduction in wages have had the smallest decline in employment. Another significant fact brought out is that there was no general movement to reduce salaries and wages until the depression had gone into its second year. Also in contrast with earlier depressions, salary reductions have tended to precede wage adjustments.

# Letters to the Editor

**CONTRIBUTIONS** to these columns are invited from Institute members and subscribers. They should be concise and may deal with technical papers, articles published in previous issues, or other subjects of some general interest and professional importance. ELECTRICAL ENGINEERING will endeavor to publish as many letters as possible, but of necessity reserves the right to publish them in whole or in part, or to reject them entirely. **STATEMENTS** in these letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the American Institute of Electrical Engineers.

## Consumption, Production, Distribution

*To the Editor:*

What takes place to produce unemployment? First we will represent the circulation of money in the form of the diagram,

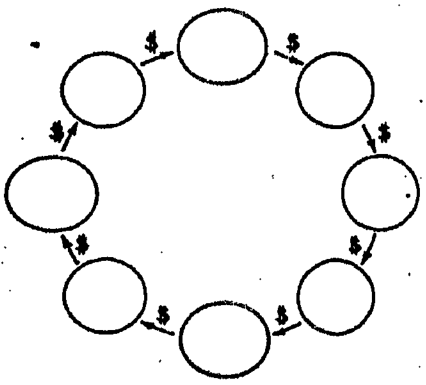


Fig. 1

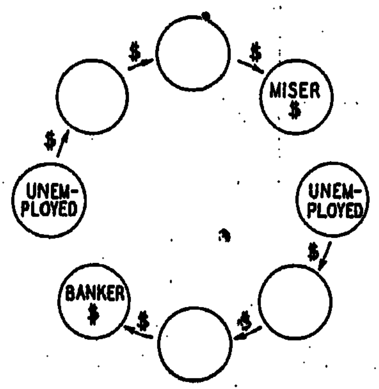


Fig. 2

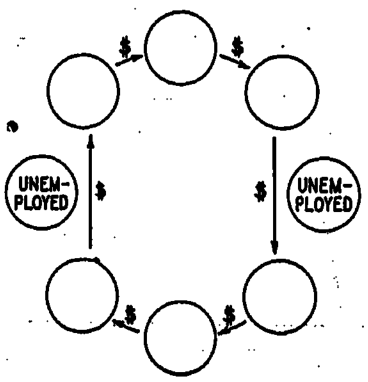


Fig. 3

Fig. 1. In this case the money is shown circulating from man to man in a perfectly organized society. Each man receives his turn at some of the money in return for some kind of goods or services.

According to the theories expressed by the progress report of the American Engineering Council ("The Relation of Consumption, Production, Distribution," ELECTRICAL ENGINEERING, June 1932, p. 373–9) there is some form of stoppage to this flow of money, which they describe by the expression that savings exceed investment. This hypothetical situation is shown by Fig. 2.

It seems entirely probable that there is some action of this kind, and that business is delayed by irregularities in the flow of money. But that this irregularity should be enough to cause a depression of the magnitude of the present seems incredible. What is more there is no evidence to support the theory. We cannot demonstrate that there was any greater irregularity in the flow of money in 1930 than in 1928. We cannot point to the men who were holding back enough money to give employment to 5,000,000 people.

A more reasonable theory of unemployment is shown by Fig. 3. This shows a normal circulation of money, but some men are left out. Instead of having in our community a population of 8, representing perhaps 8,000,000, we have but 6 and the other 2 are outside. There is no reason why a community of 6,000,000 should not get along indefinitely just as well as a community of 8,000,000. And there is no force in our economic system to make the 6,000,000 gather in the other 2,000,000, for each one can spend all of his income by exchanging within his group. No one has anything left to hire the other outsiders.

The problem of unemployment is to find some way to induce the circle to open up and take in the outsiders, for the mere fact that the outsiders are there will not induce any individual in the group to trade or hire them. At present the limiting factor appears to be a shortage of capital. Furnishing capital is a service as much as furnishing labor. The supply of capital is only enough to permit the group to be of its present size. Should more capital be saved, some of the capitalists would seek the outsiders in order to get a better and more profitable use for their capital.

Very truly yours,
A. W. FORBES (A'12)
(Forbes & Myers,
Worcester, Mass.)

**(Editor's Note: This letter is the third by Mr. Forbes discussing the economic problems covered in American Engineering Council's progress report.)**

*To the Editor:*

The special committee authorized by American Engineering Council in 1931 to study the relation between consumption, production, and distribution "interpreted its commission as being the selection and recommendation of such governmental, financial, and business policies as will maintain in the United States a standard of living that is high, broadly distributed, and free from severe fluctuations."

In attacking this problem the A.E.C. committee displayed excellent judgment in reducing the reputed number of factors bearing on the subject from 12 down to 8 and perhaps the most important of these 8 factors is that described in paragraph 5—"Controlling of money and credit to satisfy the needs of government, business, and individuals."

In publishing the full text of this A.E.C. committee progress report in the June 1932 issue of ELECTRICAL ENGINEERING, p. 373–9, the editors have rendered a time saving service by bracketing points that need emphasizing—for example that on p. 377 which will bear repeating:

"The stabilization of money is another possibility for large scale governmental and financial action. The seriousness of the lack of control of money value (or, the general price level as reckoned on a properly selected index) is beyond the power of words to express, because the world probably is in full movement on a secular decline with only minor short-lived upturns in prospect. It is important for governments and financiers to reconsider their attitudes on this question. A steadfast attempt to discover a safe and reliable means of controlling the value of money is required. Instead of being a question that is tabooed or ignored, it should be looked upon as the most important financial subject to which those in charge of the world's money can devote their energy and attention. There should be no rest until every possibility has been canvassed."

On p. 378 money and credit is involved in the A.E.C. committee's comments on public works, namely: "Herein lies an almost limitless field for the investment of private savings for public good that is socially profitable and economically stabilizing." In every relief bill offered, public works based on borrowed money have been discussed. Most of us believe that borrowed money should be repaid, and, as I write, the President's task of figuring out the rate of interest on borrowed money to be paid various parties, is the biggest point to be adjusted before the huge governmental relief bill receives his signature. Taxpayers are on the anxious seat and bankers who have the ready money (or will borrow some) must obviously figure risks as well as profits.

History records that Bellamy's book of the late eighties, "Looking Backward," inspired a hopefulness which was transferred into action by men in the electrical industry, and apparently history is about to repeat itself with hopeful plans transformed into action.

Here in Schenectady an electrical engineer from Pittsfield, Mass., recently outlined a plan involving the control of money and credit based on public works as a money standard which approached the subject in as business-like an engineering method as that employed by the A.E.C. committee in their recent progress report, and also inspired hope comparable with Bellamy's "Looking Backward."

Very truly yours,
H. W. TURNER (A'03)
(18 Troy Place, Schenectady,
N. Y.)

## Has Man Benefited by Engineering Progress?

*To the Editor:*

It seems to me that the Engineering Foundation's question "Has Man Benefited by Engineering Progress?" at once asks a question and answers it since "progress" applies only to a beneficial course of events.

An entirely different question would be "Has Man Benefited by Engineering Activity?" This last question allows inclusion of the development of war machinery and hence its answer calls for a critical and exceedingly comprehensive scrutiny of our present civilization.

Very truly yours,
P. K. SEYLER (A'26)
(Mountain States Tel. & Tel. Co., Denver, Colo.)

## Magnet Steels and Permanent Magnets

*To the Editor:*

Under the title of "Magnet Steels and Permanent Magnets" an article was published by K. L. Scott in the May 1932 issue of ELECTRICAL ENGINEERING, p. 320–3. I should like to make some remarks about this subject, explaining theoretically the experimental data of the work of Scott. Scott measures the induction $B_{rem}$ in the middle of rectilinear bar magnets of different steels, lengths $L$ and cross-sections $A$, and finds that $\frac{B_{rem}}{B_r}$ is only a function of $\frac{L}{D}\sqrt{\frac{H_c}{B_r}}$, where $B_r$ = remanence in closed circuit, $H_c$ = coercive force, $L$ and $D$ = equivalent diameter. Thus:

$$\frac{B_{rem}}{B_r} = \mathrm{f}\left(\frac{L}{D}\sqrt{\frac{H_c}{B_r}}\right) \qquad (1)$$

The form of this function is given in Fig. 2 of the article by Scott, which figure we reproduce here as Fig. 1.

Scott first tried to plot against $\frac{L}{D}\sqrt{H_c}$ but found it preferable to plot against $\frac{L}{D}\sqrt{\frac{H_c}{B_r}}$. We will show that the last method of plotting is the one to be theoretically expected.

The demagnetizing coefficient $N$ of a rectilinear bar which is not too short compared to its cross-section is given by:

$$N = 4\pi\beta^2\left(\log\frac{2}{\beta} - 1\right) \qquad (2)$$

where $\beta = \frac{D}{L}$ (this formula is valid exactly for an ellipsoid and for $\beta$ small).

$N$ being known for a special bar, we find the remanence $B_{rem}$ in the middle of the bar, as Fig. 2 shows, as the intersection point $P$ of the line $S$ and the demagnetization curve, if $\tan\alpha = \frac{H}{B} = \frac{N}{4\pi}$ (divided by $4\pi$ because we plot $B = 4\pi\mathcal{J} + H$ instead of $\mathcal{J}$, which is the intensity of induced magnetization).

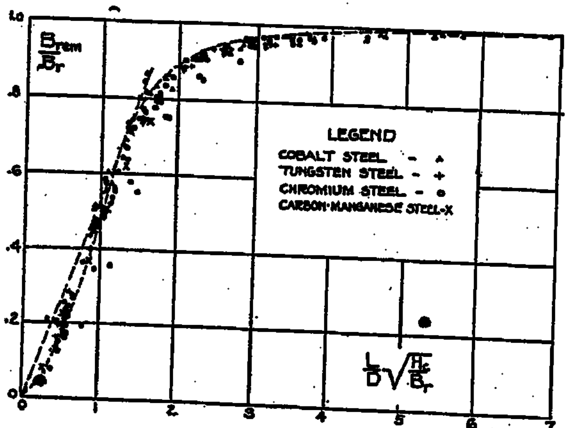


Fig. 1

Now experiments of R. L. Sandford (Bureau of Standards scientific paper No. 567 published in 1927) show that the demagnetization curves of all steels have nearly the same shape. If we therefore transform Fig. 2 into Fig. 3 by introducing the variables $\frac{B}{B_r}$ and $\frac{H}{H_c}$ instead of $B$ and $H$, respectively, the demagnetization curves of different steels fall on the same curve. In Fig. 3 we draw the line $S$ making the angle $\alpha'$ with the ordinates:

$$\tan\alpha' = \frac{H/H_c}{B/B_r} = \frac{H}{B} \times \frac{B_r}{H_c} = \frac{N}{4\pi} \times \frac{B_r}{H_c}$$

The point $P$ gives the value of $\frac{B_{rem}}{B_r}$ in the middle of the bar and as the demagnetization curve of Fig. 3 is valid for all steels, the value of $\frac{B_{rem}}{B_r}$ is only a function of $\alpha'$, that is, of $\frac{N}{4\pi} \times \frac{B_r}{H_c}$.

Thus:

$$\frac{B_{rem}}{B_r} = \varphi\left(\frac{N}{4\pi}\frac{B_r}{H_c}\right) = \varphi\left[\beta^2\left(\log\frac{2}{\beta} - 1\right)\frac{B_r}{H_c}\right]$$

In first approximation we neglect the variation of $\left(\log\frac{2}{\beta} - 1\right)$ so that we write:

$$\frac{B_{rem}}{B_r} = \varphi\left(A\beta^2\frac{B_r}{H_c}\right) = \varphi\left(A\frac{D^2}{L^2}\frac{B_r}{H_c}\right) = \mathrm{f}\left(\frac{L}{D}\sqrt{\frac{H_c}{B_r}}\right)$$

$\frac{B_{rem}}{B_r}$ is thus a single-valued function of $\frac{L}{D}\sqrt{\frac{H_c}{B_r}}$ as long as $\left(\log\frac{2}{\beta} - 1\right)$ may be considered as constant, and for values of $\beta$ not too large, because for large $\beta$, eq. 2 does not hold.

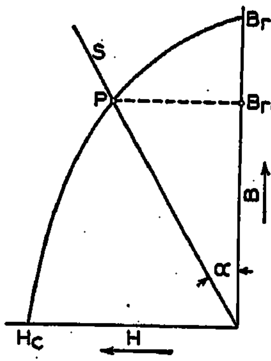


Fig. 2

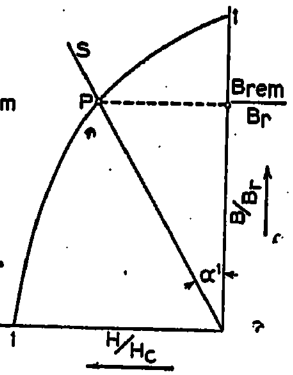


Fig. 3

As shown experimentally by Scott, the line in Fig. 1 through the origin and tangent to the curve has its point of tangency in the point corresponding to the point of maximum economy on the demagnetization curve (i. e., the point where $B \times H$ is at its maximum).

To show this and to calculate the function $\mathrm{f}\left(\frac{L}{D}\sqrt{\frac{H_c}{B_r}}\right)$, that is, to calculate the curve of Fig. 1 we must make an assumption regarding the shape of the demagnetization curve. I found good agreement with experiment (see W. Elenbaas, Physica, v. 9, 1930, p. 273) by taking the demagnetization curve as a quadrant of an ellipse. Therefore we write the equation of the demagnetization curve as:

$$\frac{H^2}{H_c^2} + \frac{B^2}{B_r^2} = 1 \qquad (3)$$

We find $B_{rem}$ as the intersection point of this ellipse with the line $S$ (Fig. 2). The equation of $S$ is:

$$\frac{H}{B} = \frac{N}{4\pi} = \beta^2\left(\log\frac{2}{\beta} - 1\right)$$

In first approximation we regard $\left(\log\frac{2}{\beta} - 1\right)$ as constant.

Thus:

$$\frac{H}{B} = \beta^2 A \qquad (4)$$

Eq. 3 and eq. 4 give:

$$B^2_{rem} = \frac{1}{\frac{A^2\beta^4}{H_c^2} + \frac{1}{B_r^2}}$$

$$\frac{B^2_{rem}}{B_r^2} = \frac{x^4}{A^2 + x^4} \text{ if we take } x = \frac{L}{D}\sqrt{\frac{H_c}{B_r}}.$$

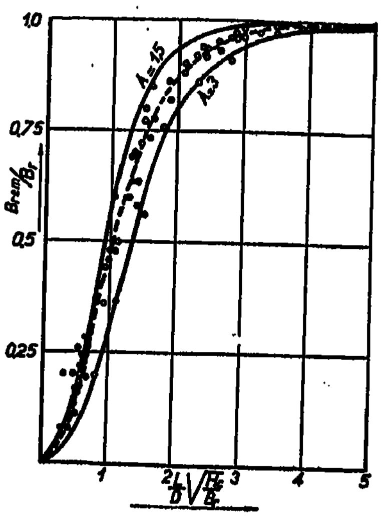


Fig. 4

Here again we find that $\frac{B_{rem}}{B_r}$ is only a function of $x$ and for the form of that function we find:

$$\frac{B_{rem}}{B_r} = \frac{x^2}{\sqrt{A^2 + x^4}}$$

Indeed this is a function similar to the curve of Fig. 1. In Fig. 4 we draw this function for 2 values of $A$, namely $A = 1^1/_2$ and $A = 3$, these being about the extreme values of $A$ in the experiments of Scott. The experimental points (a large number of the points of Scott are plotted in Fig. 4) fall satisfactorily between these 2 curves, except some points at low values of $x$. This is probably due to the fact that $\beta$ for these bars was so great, that eq. 2 did not hold (the greatest value of $\beta$ used by Scott was about $\frac{1}{5}$).

We find the point of tangency of the curve $\frac{B_{rem}}{B_r} = \frac{x^2}{\sqrt{A^2 + x^4}}$ with the line through the origin by making $\frac{B_{rem}}{xB_r} = \frac{x}{\sqrt{A^2 + x^4}}$ a maximum.

This gives $x = \sqrt{A}$
and therefore

$$\frac{B_{rem}}{B_r} = \frac{A}{\sqrt{2A^2}} = {}^1/_2\sqrt{2}$$

and in the case of an ellipse this corresponds indeed to the point of the demagnetization curve, where $B \times H$ is a maximum. The value ${}^1/_2\sqrt{2} = 0.7$ is in good agreement with the experimental value derived from the curve of Fig. 1, namely 0.65.

In this way it is possible to interpret fully the curve as found by Scott.

Very truly yours,
W. ELENBAAS
(Natuurkundig Laboratorium der N. V. Philips' Gloeilampenfabrieken, Eindhoven, Holland)

## Savings and Investment

*To the Editor:*

Mr. Forbes in his letter printed in the July 1932 issue of ELECTRICAL ENGINEERING, p. 527, regarding the American Engineering Council's progress report on consumption, production, and distribution, apparently put his finger on the sore spot without knowing it.

Referring to his illustration, suppose Mr. Smith keeps the $3, saves it. Mr. Brown keeps the hat. Brown may be the owner of the hat factory, Smith his employee. Anyhow, Brown has goods for sale, Smith is a prospective consumer, who has earned $3. No business is done, and we have "depression." Now if Smith's saving is invested, it goes to work, is paid to some one for building "capital goods," and a second consumer has the $3 and can buy the hat. The important thing is obviously movement, not a static equation showing the status of any particular $3 at any particular instant. The time element must be introduced.

The difference between savings and investment in the report is crucial; and the integration of these items over a time period (or else the rate with respect to time) is implied. It simply means finding the spot where the system is clogged. The volume of trade is forced to decelerate by diversion of purchasing power into the reservoir of hoarded wealth.

Where this hoarded wealth may be found has been disclosed by much material recently published. Another way of saying this is that there was a contraction of currency and credit. This did occur in 1929, contrary to Mr. Forbes, and the process has continued since then. The details involve an insight into our banking and credit structure, which is beyond the scope of this letter.

Very truly yours,
C. T. BUTTON (A'26)
(1133 Chamber of Commerce Bldg., Cincinnati, Ohio)

## Young Engineers Must Plan for the Future

*To the Editor:*

For a number of years I have been endeavoring to interest the most promising among our electrical engineering seniors and graduate students in thinking of our profession 10 to 20 years ahead of their time. It usually takes that long for a natural leader to reach a position in which he can actually lead a considerable group of workers. I always wanted such men to get at least a general idea of the directions in which our art and industry were moving at the time, so as to acquire the necessary mental equipment in the meantime. In 1905 I talked to them of huge transmission lines and of the necessity of understanding how to compute them both electrically and mechanically. About 1910 we had a chosen group struggling with transient phenomena and with plotting of electric and magnetic fields. In 1915 I used to annoy my graduate students by incessantly talking about electrons and about the important rôle they were going to play in electrical engineering. Then came the Heaviside calculus, power plant stability, thermionics, and what not.

For years this country has been handicapped in the development of electrical apparatus and in understanding some operating troubles by the false belief (natural in a pioneer country with only 2 political parties) that physicists, chemists, and mathematicians discover and investigate fundamental laws upon which the art of the engineer is based, and we engineers merely apply these laws and data to our problems. The Germans have developed a much more practical and flexible hierarchy of pure scientists, applied scientists, theoretical engineers, and practical engineers, with almost imperceptible gradations among them. The result has been that in Germany an operating trouble can be handed down (or perhaps up) from a practical engineer to a theoretical engineer; from the latter, in a modified form, to an applied scientist, and sometimes in the form of a general problem even to a pure scientist. With us, until a few years ago, if an operating engineer had trouble with some oil or paint he had to lay his story before a professor of chemistry who was liable to talk to him in terms of hydroxi-derivatives of phenanthraquinone, leaving the operating man exactly where he was before. It was partly this unsatisfactory situation which finally led to the formation of large research departments in our leading manufacturing and operating organizations. Nevertheless, there are still numerous gaps in many places. We need several types of middlemen between the pure sciences and the engineering art, and we need them urgently. Probably such intermediate men are also needed in economics and psychology, but this is another story for some one else to discuss.

It is with this idea in mind, namely, to increase the number of young theoretical engineers and applied scientists in this country, that I now urge intelligent students and former students to look forward not to an immediate job (or absence of one, as the case may be), but to a time when our industry shall demand an intelligent judgment about the group theory and restricted relativity in mathematics, theoretical spectroscopy and wave mechanics in physics, and an interpretation of the molecular structure and chemical reactions in terms of the quantum theory. All this may sound far fetched, but I remember the time when only a few chosen ones could handle alternating currents in terms of ordinary trigonometry, and when a d-c network computed by Kirchhoff's laws was sometimes checked on a small model, "just to be sure."

It is an ill wind that blows nobody good, and in these days of adversity and depression an ambitious young engineer with scientific leanings can do no better than to study the fundamental sciences and thus prepare himself for a place of middleman and interpreter in some specific problem of the industry of the future. The general tendency undoubtedly will be in the direction of more reliance on pure sciences, more accurate predetermination of performance of apparatus, and a rational analysis of troubles. No matter in which suitable branch of mathematics, physics, chemistry, or mechanics he decides to become an expert, he will be working toward ultimately becoming "geared" to the industry in an organic way, whereas one who shall place his reliance mainly upon good health, pleasing sociable personality, and a general idea of what a shunt wound d-c machine is, may later find himself in a long line of applicants with similar qualifications, all waiting for the same 15-dollar-a-week job. With the dawning socialization of the industries, the days of the glib-tongued salesman and prosperity manager are about over, and the truly scientific engineer will be soon coming into his own.

This letter is not the place to indicate specifically which topics I consider to be of importance in the future. The very process of finding fruitful paths of pioneering is an important part of the proposed studies, as well as a test of one's fitness for future leadership. Whatever subject one undertakes to master must be organically (although perhaps yet in a hidden way) connected with the present progress of the art, and not merely join it at some distant future. Anyone who would take the trouble of going over the Institute TRANSACTIONS, say for the last 10 years, keeping the forthcoming trends in view, will find any number of inspiring hints and clues. A similar study of the leading European periodicals devoted to electrical engineering should be the next step. Then, having decided to follow, say, some features of the science of electronics, the best American journals of physics should be gone over, and finally a detailed program of study arrived at. After this, it is merely a matter of finding suitable books and perhaps forming a connection with an experienced specialist for guidance and advice.

Very truly yours,
VLADIMIR KARAPETOFF (F'12)
(Cornell University, Ithaca, N. Y.)

## Suggested Changes in Dielectric Nomenclature

*To the Editor:*

I note with interest the increasing effort on your part to make our monthly publication a direct expression of the profession.

I am particularly interested in your publication of timely letters addressed to the Editor. I read with much interest a letter by Hubert H. Race (A'24) suggesting changes in dielectric nomenclature (see ELECTRICAL ENGINEERING for May 1932, p. 354–5). I approve Mr. Race's suggestions and believe there are many instances in which an improved nomenclature would make for clarity and convenience of expression in the electrical engineering art.

I have in mind a particular instance where I believe an improved nomenclature and the adoption of the name for a unit would be of advantage. I have in mind the unit of electric field intensity or voltage distribution per unit of length. This unit is now customarily expressed as volts per foot, or volts per inch, or volts per centimeter. I believe a single name for this unit, preferably called after some distinguished pioneer in this art, to be a desideratum.

I, therefore, take the liberty of proposing that the c.g.s. electrostatic unit of electric field intensity be called the "Franklin."

Very truly yours,
WM. W. FRASER (M'27)
(6 East 45th Street, New York, N. Y.)

## Patents on Arc Welding Generators

*To the Editor:*

We refer to p. 527, July 1932 issue of ELECTRICAL ENGINEERING, "Letters to the Editor," entitled "Eliminating Transients in a D-C Welding Generator" and more definitely with regard to the public assertion that J. Bethenod now has a patent on this double wound reactor for controlling the arc in a welding generator. We would like to have this letter published.

The writer was granted U.S. Patent No. 1,549,874, August 18, 1925, on this scheme. The scheme was invented and improved to practise sometime previously and if the patent laws of France were similar to the laws of the United States, Mr. Bethenod would not have obtained any patent on this.

In deference to the insinuation against the other 2 leading companies in arc welding, both of these are licensed under our patent and are probably, accordingly, interested in Bethenod's later development because in this country the man who does it first obtains the patent, and if it has been published, patented, described, or used in any other country, no patent can be obtained in this country. The writer believes he was the first to discover the use of static transformer control of an arc welding generator.

This transformer arrangement of the old familiar series reactor is a wonderful improvement, theoretically and practically. In self-excited machines the discharge into the hands of the operator is dangerous. In separately excited sets, the insulation should be of a special nature to insure that this doesn't happen. The trouble lies in applying the induced voltage to the shunt field which has high values to counteract. The same effect can be had by applying this voltage to the series field and here the values are so low that many times them are still less than the arc voltage.

Very truly yours,
C. J. Holslag (M'19)
(President, Electric Arc Cutting & Welding Company,
152 Jelliff Ave., Newark, N. J.)

(Editor's Note: This letter is an extension of one phase of Mr. Holslag's letter which was published in Electrical Engineering for January 1932, p. 59.)

# Standards

## Proposed Electrical Definitions Now Available in Report Form

The report on the proposed "American Standard Electrical Definitions" upon which the sectional committee on electrical definitions has been working for over 3 years now is available in a pamphlet of 208 pages. The project, which had its initiation in 1928 in the recommendation of the A.I.E.E. standards committee, has been carried on in full accordance with the rules of procedure of the American Standards Association and under the sponsorship of the Institute.

This work required the formation of 17 subcommittees with a total personnel of about 120, the additional expert help sought increasing the number cooperating to over 300. The individual reports of the subcommittees have been widely circulated for criticism and comment in each of their several stages of development. Controversies on proper wording naturally have developed in many instances. In most cases, the subcommittees have been able to arrive at an acceptable solution within their own groups. In cases of overlapping fields the executive committee under the able guidance of Chairman A. E. Kennelly has been called into action. Even after the most earnest efforts to eliminate conflicting definitions, it will be noted that certain conflicts still exist. It was felt to be very desirable, however, to issue the report as it now stands with the hope that circulation in pamphlet form would result not only in obtaining still further suggestions of a helpful nature, but might lead perhaps to a solution of the questions still unsettled.

In collecting and compiling the definitions which served as the original basis of the committee's work, it soon became evident that there existed conflicting definitions of identical terms, all having the status of American standards. In most such instances the sectional committee on electrical definitions has selected what appeared to it to be the most desirable wording. In other cases it has been felt desirable to suggest for a term or concept a wording differing from an accepted standard. The object in view always has been the development for each term of a wording expressing the meaning generally associated with it in electrical engineering in this country. When possible, definitions have been generalized so as not to preclude the different specific interpretations attached to particular applications.

The sectional committee wishes to express its sincere appreciation of the spirit of cooperation which it has met on all sides, and acknowledges its indebtedness to all organizations and individuals having given so freely of their time and experience. The assistance obtained from glossaries issued by various technical organizations, particularly the British, and the experience of the secretariat on nomenclature of the International Electrotechnical Commission, have been particularly helpful.

The glossary in its present state is incomplete, but it is impractical to carry through the entire program at one time. The cost involved to date has been great; therefore it has been found necessary to make a nominal charge for copies. This price has been set at $1 per copy, with the usual 50 per cent discount to members of the A.I.E.E.

Address all communications to A.I.E.E. Headquarters, 33 West 39th Street, New York, N. Y.

# Personal

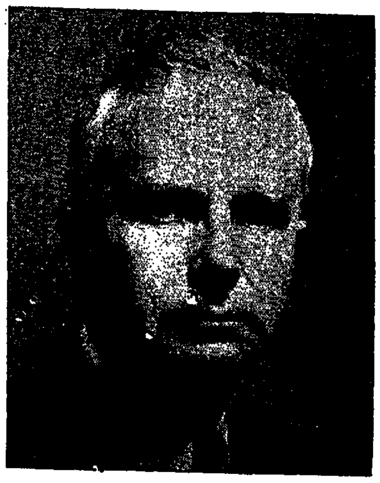
H. S. Osborne (A'10, F'21) who is now transmission engineer of the American Telephone and Telegraph Company, New York, N. Y., is to continue his chairmanship of the Institute's technical committee on communication for the ensuing year. He was born at Fayetteville, N. Y. From Massachusetts Institute of Technology he received his B.S. degree in 1908 and his doctor of engineering degree in 1910. During his college course he engaged summers in engineering positions which gave him a varied experience. In 1910 he joined the engineering department of the American Telephone and Telegraph Company as engineer in the transmission and protection department. Here he assisted in many developments in telephone and telegraph engineering, including quadded cable and the systematic study of interference in telephone circuits. In April 1914 he was made assistant to the transmission and protection engineer, and in this new office assisted in the establishment of the transcontinental telephone. Under the general direction of the transmission and protection engineer he also was in responsible charge of many important developments. In 1920 he was appointed transmission engineer and as such has assumed the responsibility for assisting all companies of the Bell Telephone System in connection with telephone and telegraph transmission and protection matters, advising regarding the proper use of new developments and carrying out exhaustive studies to determine the most desirable plant practises. Mr. Osborne has served as representative of the Institute on the American Standards Association from 1923 to date, at one time being assistant treasurer of the A.S.A. He also has served on the A.I.E.E. standards committee 1917–28 (chairman 1923–26); committee on education 1928–31; communication committee 1929–32 (chairman 1931–32); technical program committee 1924–25, 1927–29, 1931–32; and upon the electrical standards committee of the American Standards Association as an alternate representative of the A.I.E.E. 1931 to August 1932, when he was appointed a representative. Mr. Osborne now is vice-president and treasurer of the U.S. national committee of the International Electrotechnical Commission with which he has worked for many years. His memberships include the American Physical Society, the American Association for the Advancement of Science, the Acoustical Society of America, Engineering Foundation, Institute of Radio Engineers, and the Montclair (N.J.) Society of Engineers, of which he is also past-president. His contributions to technical literature have been numerous.

H. S. OSBORNE

E. J. Rutan (A'20, M'29) supervisor of the test bureau of the New York Edison Company, with which he has been associated for over a decade, has received reappointment as chairman of the Institute's technical committee on instruments and measurements for the current year. Brooklyn, N. Y., is Mr. Rutan's place of birth. After completing a course at Cornell University from which he received his M.E. degree with certificate in electrical engineering, he joined the test department of the New York Edison Company in 1919 as a tester. Within a short time he

K.L. HANSEN

S. L. HENDERSON



W. A. HILLEBRAND

E. J. RUTAN

had advanced to foreman; then he became general foreman, assistant superintendent, and ultimately superintendent. Since 1924 he has been in responsible charge of the company's test work. In 1930 the name of the test department was changed to test bureau and Mr. Rutan became supervisor; the work continued to cover all testing carried on by the company, including acceptance tests of all materials received in the store room, machinery for stations, and all equipment for transmission and distribution systems. Also all special testing for development and research purposes is conducted in this bureau to maintain electrical standards for the company in connection with primary standard cells, resistors, and potentiometers. Mr. Rutan was a member of the Institute's technical committee on protective devices, 1924–27; a member of the subcommittee on standards for measurements of voltages in dielectric tests, 1925–26; and in 1927 was appointed to the subcommittee called to draft standards for constant current transformers; his appointment to the technical program committee took place in 1930. Since 1926 he has served on the instruments and measurements committee, having been its chairman since 1930. As a member of the American Society for Testing Materials, he has served on its committee D9 on electrical insulating materials 1927–29, and now again in 1932.

**W. A. Hillebrand** (A'08, M'13) previously electrical engineer for the Ohio Insulator Company Division of the Ohio Brass Company, at Barberton, Ohio, a position which he had held since 1919, has returned to the academic field and in August 1932 will assume new duties in accepting a professorship in electrical engineering at the University of California, Berkeley, Calif. In a consulting capacity however, he will continue his affiliation with his commercial interests. Graduating from Cornell University in 1905, Mr. Hillebrand extended his studies to include a year at Stanford University, Calif. Through employment in the Pacific Coast office of the Western Electric Company 1906–7, he continued to broaden his experience. The period 1907–14 was occupied as instructor under Doctor H. J. Ryan at Leland Stanford University and as professor of electrical engineering at the Oregon State College, Corvallis, Ore. In June 1914 he joined the Pacific Gas and Electric Company (Calif.); for 2 years he was engaged with the Federal Telegraph Company (Calif.) in the manufacture of arc radio transmitters. His first identification with the Ohio Brass Company at Mansfield, Ohio, was as a commercial engineer, still centering his activities upon the Pacific Coast, but traveling over all parts of the United States and Canada, even spending some 8 months in Japan. In 1925 he went to Barberton, Ohio, as consulting electrical engineer for the Ohio Insulator Division of his company, thus returning to his native State. Mr. Hillebrand's place of birth was Perrysburg, Ohio, but he grew up in Washington, D. C. Besides his membership in the A.I.E.E., he is a member of the Institute of Radio Engineers and also of the Schweizerisher Elektrolechnischer Verein of Zurich.

**K. L. Hansen** (A'17) now carrying on a consulting engineering practise in Milwaukee, Wis., under the company name of K. L. Hansen Engineering Company, Inc., has been appointed to serve as chairman of the Institute's technical committee on electric welding for the current year, a committee of which he has been a member for the past 2 years. Mr. Hansen was born in Norway and came to the United States early in 1901. For 2½ years he worked in various shops in Chicago, most of the time for the Western Electric Company, assembling fan motors and arc lamps. In the fall of 1903 he entered the University of Illinois. From the summer of 1905 until early in 1906 he found employment with the Chicago Edison Company, first as splicer's helper in the underground cable department and later as substation operator. In February of that year he removed to East Pittsburgh, Pa., and joined the Westinghouse Electric and Manufacturing Company, working for a year and a half successively as wireman, tracer, and draftsman. His company then transferred him to the dynamo testing department where he remained for nearly 4 years or until he again was transferred, this time to the industrial engineering department, to become designing engineer for d-c motors and generators. He remained in the employ of the Westinghouse company until in the fall of 1919 he left it to join the Louis Allis Company (then the Mechanical Appliance Company) of Milwaukee. Here again he engaged in the capacity of designing engineer, this time for a-c and d-c motors and generators, later becoming chief engineer. It was upon severing his connection with the Louis Allis Company that he entered upon consulting and development work of his own. The Hansen arc welder, first built and marketed by the Northwestern Manufacturing Company, of Milwaukee, until the early part of 1932 and later taken over by the Harnischfeger Corporation of that city, was invented and designed by Mr. Hansen, whose own company, the K. L. Hansen Engineering Company, Inc., is now marketing it. He developed a number of arc welding processes, the Hansen arc torch being one of them. He also holds patents, jointly with another, on self-starting induction motors and self-starting compensated induction motors. During the past 5 years Mr. Hansen has given numerous addresses before technical societies and conventions, chiefly on the subject of arc welding and its many applications.

**S. L. Henderson** (A'12) division engineer of the power engineering department of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and since 1928 a member of the Institute's technical committee on electrical machinery, has received reappointment as its chairman for the current term of service ending August 1933. Mr. Henderson is a native of Roxbury, Mass.; upon completion of his public school work in Boston, he entered Massachusetts Institute of Technology. In July 1910 he joined the test department of the Westinghouse Electric and Manufacturing Company at East Pittsburgh, and by 1912 was holding a position of responsibility with that company. For a number of years he was in charge of turbine generator design for the Westinghouse company; his present work is in charge of design of large synchronous and induction motors. He also has been active as a committee-man for other technical bodies of professional importance, having served on the American Standards Association's sectional committee on rotating machinery; A.S.A. subcommittee on definitions; and subcommittee 1-C on wave shape, of the National Electric Light Association's joint committee on development and research in collaboration with the Bell System. In addition to his service on the electrical machinery committee of the A.I.E.E., Mr. Henderson has been active as a member of its subcommittee on synchronous machines.

**W. C. Smith** (A'07, M'26) succeeds **R. F. Monges** (A'08) to the position of district engineer of the San Francisco, Calif., office of the General Electric Company, June 1932. Mr. Smith has been with the company since 1905 in varying capacities, joining the organization the same year he was graduated from the University of Michigan. In 1907 he became a member of the transformer engineering department and until 1918 worked both at Pittsfield, Mass., and Schenectady, N. Y., supplementing this experience with 2 years spent in special investigations for his company at Denver, Colo., before taking office at San Francisco as transformer, meter, and regulator specialist. He has been Mr. Monges' assistant for the past year. In 1925 he was awarded the Coffin Medal, which is given annually by the General Electric Company, "for the most signal contributions toward increase in efficiency or progress in the electrical arts"; he is past-chairman of the company's Pittsfield Section, and recently was elected vice-chairman of the A.I.E.E. San Francisco Section, which he already has served during the past year as secretary. Other organizations to which he belongs are the San Francisco Electrical Development League, the San Francisco Engineers' Club, the Pacific Coast Electrical Association, and the Astronomical Society of the Pacific Coast.

**W. J. Mowbray** (A'03, F'31) previously operating as meter engineer at Cranston, R. I., and for the period 1919–30 research and test engineer as well as educational director for the Narragansett Electric Lighting Company of Providence, R. I., now has received his appointment as instructor in electrical engineering at the Rhode Island State College, at Kingston, R. I. During the whole of the above mentioned period Mr. Mowbray was serving the New England Section of the National Electric Light Association on its meter committee, of which he for one year was chairman; he also was a member of the A.I.E.E. instruments and measurements committee 1924–29.

**L. A. Magraw** (A'07, M'13) who at a recent conference was chosen to serve as president of the National Electric Light Association's Southeastern Division, has relinquished the presidency of the South Carolina Power Company, of Charleston, S. C., to become president of the Central Illinois Public Service Company, Chicago, Ill. Mr. Magraw received his degree of B.S. in E.E. from Worcester Polytechnic Institute; his achievements in electrical engineering have been outstanding for over 20 years, most of them having been in the South where he has been active since 1909.

**R. E. Doherty** (M'27) who last year resigned from his many years of service as consulting engineer of the General Electric Company, Schenectady, N. Y., to become professor of electrical engineering at Yale University, New Haven, Conn., continues his chairmanship of the Institute's education committee for the year following August 1, 1932. Mr. Doherty's native State is Illinois; he was graduated from the University of Illinois in 1909, at that time receiving his B.S. degree, and later, in 1921, his M.S. was won from Union College (Schenectady, N. Y.). He entered upon the General Electric Company's training course at Schenectady in 1909 and for 2 years was occupied in its test department. At the end of that time he was transferred to the a-c engineering department as proposition designing engineer. Here his work was observed by C. P. Steinmetz, who in 1920 chose Mr. Doherty as his assistant. It was while engaged in this work that he took his postgraduate course at Union College. The next year he became consulting engineer of the General Electric Company. In addition to duties devolving upon him as consulting engineer he has had charge of an advanced course in engineering specially planned by his company for a small and selected group of college graduates. This, a 3-year course, is practical professional work. He also was a member of the General Electric Company's general education committee. Institute committees upon which Mr. Doherty already has served are: education 1918–19, 1926–28, 1931–32 (chairman); electrophysics 1924–26; power transmission and distribution 1928–29; and technical program 1931–32. He also has served as chairman of the Institute's Schenectady (N. Y.) Section 1926–27. Mr. Doherty's contributions to technical literature have been numerous, both as regards papers of his own preparation and his discussion of those presented by others.

R. E. DOHERTY

**W. P. Taylor** (A'26) who ever since his graduation from Johns Hopkins University in 1923 has been associated with the Consolidated Gas, Electric Light and Power Company, at Baltimore, Md., was chosen to receive the 1931 A.I.E.E. Middle Eastern District prizes for both best paper and initial paper for his contribution entitled "Locating Power Cable Faults by Means of a Constant-Current Transformer With Short-Circuiting Switch." Mr. Taylor was born at Waterbury, Conn., but practically all his life has been spent in the state of Maryland. Prior to attending Johns Hopkins University, he spent 4 years in study in the grade schools of Stockton, Md.; his graduation from Johns Hopkins in 1923 was with the degree of B.E. in E.E. Immediately thereafter his work with the Consolidated Gas, Electric Light and Power Company of Baltimore started with his assisting in the conducting of tests on all kinds of electrical apparatus in the company's research and test departments. His present work covers chiefly the planning and conducting of tests on electrical appliances. One of the special investigations conducted was an attempt to determine the comparative life of various rubber compounds used as insulation for wire; another a study of power cable fault locating in an effort to eliminate some of the troubles commonly encountered in this field.

W. P. TAYLOR

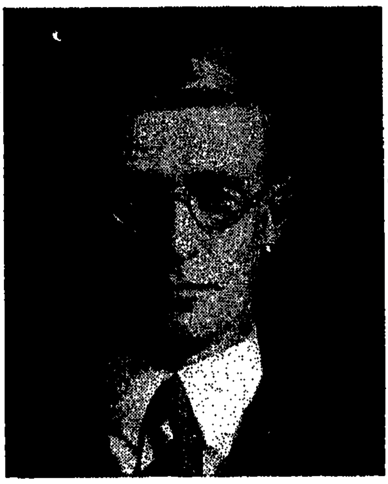
**R. F. Monges** (A'08) for 35 years district engineer of the San Francisco, Calif., office of the General Electric Company, retired as of June 1932. He is succeeded by W. C. Smith (A'07, M'26), who has been with the company as transformer sales engineer and Mr. Monges' assistant. Prior to becoming district engineer, Mr. Monges had held office with the company as assistant engineer for 8 years; he also had spent 2 years in the G. E. test department. This was immediately after his graduation from an electrical engineering course which he took at the University of California.

**C. E. Smith** (A'32) who during 1930–31 was student engineer for the RCA Victor Company, Inc., at Camden, N. J., working in the company's development and research laboratories, now has achieved the position of electrical engineer for The Radio Air Service Corporation, at Cleveland, Ohio, having been graduated last June from Ohio State University with the degree of M.S. in electrical communication engineering.

**W. R. Thorson** (A'26) who at one time was superintendent of electrical distribution for the Consumers Power Company, at Hudson, Mich., and later was in the distribution engineering department of that company at Jackson, Mich., now has been made superintendent of public works at Waverly, Ia.

**Vannevar Bush** (A'15, F'24) who recently became vice-president and dean of engineering at Massachusetts Institute of Technology at Cambridge, Mass. (see

Electrical Engineering, April 1932, p. 286, for a brief record of Doctor Bush's professional record), recently received reappointment as chairman of the Institute's technical committee on electrophysics. Doctor Bush already has served an unbroken record since 1924 upon this committee; his chairmanship dates from 1931.



VANNEVAR BUSH

G. M. Griffith (A'23) intermittently during the past 6 years has been identified with Latin-American utilities in Cuba, Costa Rica, and Venezuela; now he has returned to Atlanta, Ga., where he was once in the engineering department of the Georgia Railway and Power Company, to open a consulting engineering office of his own.

A. L. Abbott (A'06, M'13) engineer of the Society for Electrical Development, New York, N. Y., recently assumed the title of engineer of the uniform legislation department of the National Electrical Manufacturers Association, New York, N. Y.

D. McK. Greer (A'31) who was engineer in the watthourmeter section of the meter engineering department of the Westinghouse Electric and Manufacturing Company, at Newark, N. J., recently became an engineer of the American Instrument Company, in Washington, D. C.

C. A. Brown (A'23) who has been doing consulting engineering work for the Union Gulf Line, New York, N. Y., now is southeastern sales representative for the De La Vergne Engine Company, in Philadelphia, Pa.

C. M. Burrill (A'25) has left the position of research engineer with the Rogers-Majestic Corporation, Ltd., Ontario, Can., to return to the RCA Victor Company, Inc., of Camden, N. J., where he will serve in the research division.

J. L. Carr (A'24) for the past year or so salesman for the General Electric Company at Washington, D. C., has joined the Potomac Electric Power Company of that same city according to notice just received at Institute headquarters.

C. I. B. Henning (A'13) past-president of the Sporting Arms and Ammunition Manufacturers' Institute, New York, N. Y., and a stockholder in various corporations in this field of activity, recently retired from business.

Alfred Ruttiman (A'15) who has been serving the Florence Stove Company of Gardner, Mass., as research engineer, recently became experimental engineer for the Alaska Freezer Company, of Wichendon, Mass.

W. G. Woolfolk (M'16) who has been doing consulting engineering work under the name of W. G. Woolfolk and Company, Chicago, Ill., recently became president of the Detroit City Gas Company, at Detroit, Mich.

F. A. Davis (M'31) who has been with the Telephone Bond and Share Company, Kansas City, Mo., now has joined the Portsmouth Home Telephone Company, at Portsmouth, Ohio.

E. R. Hartman (M'31) who has been associated with the Telephone Bond and Share Company, at Kansas City, Mo., recently joined the Nebraska Continental Telephone Company, at Columbus, Neb.

J. W. Hancock (A'10) who is manager of the Appalachian Electric Power Company at Roanoke, Va., has been elected president of the southeastern geographic division of the National Electric Light Association.

W. H. Sammis (A'20) of New York, N. Y., recently was elected a director of the Consumers Power Company, Jackson, Mich. Mr. Sammis formerly was located in the general offices of that company at Jackson.

# Obituary

Thaddeus Reynolds Beal (A'03) president and general manager of the Central Hudson Gas and Electric Corporation, Poughkeepsie, N. Y., died August 10, 1932, of a heart attack which came upon him while he was at Nantucket, Mass. Mr. Beal was born in New York City, June 1870, and was educated at the College of the City of New York, graduating from its engineering course in 1889. His father, William Beal, was the founder of the original power company in Newburgh, N. Y., and for 12 years, through a series of consolidations of Poughkeepsie, Newburgh, and New York City organizations, Thaddeus Beal found practical experience with the gas and electric business of these cities. The Central Hudson Corporation was a culmination of some of these consolidations, the merging of the Poughkeepsie Power Company and the Newburgh Gas and Electric Company in 1911 forming the nucleus. Of this new firm, formed after the death of his father, Mr. Beal was general manager, as he had been consecutively of the Newburgh Light, Heat, and Power Company and the Poughkeepsie Light, Heat, and Power Company. On the first of January 1927 he became president of a consolidation involving some 65 eastern gas and light concerns. Mr. Beal was a member of the American Gas Institute, the Society of Gas Lighting, the Engineers' Club of New York, Delta Kappa Upsilon, and was on the executive board of the New York Y. M. C. A. He had also served as a naval officer during the Spanish-American War.

William Ramsey Hendry (A'05) for the past 25 years active in the electrical industry upon the West Coast, and at the time of his death proprietor and manager of the W. R. Hendry Company at Seattle, Wash., died recently at his home in that city. A native of Montreal, Can. (1875), he removed to Tacoma, Wash., in 1892 and engaged with the construction department of the Thompson-Houston Electric Company. Early in 1893 he was transferred to the general repair shop of the General Electric Company in Portland, Ore., but in the fall of the year he returned to Tacoma and entered the high school for a 2-year period. He then became armature winder for the City Park Railway Company, Tacoma, for 2 years, after which he was identified with the Bernard's Bay Mining and Milling Company, Seward City, Alaska, for a year, in charge of the installation and operation of lighting and power machinery. His next affiliation was with the Coney Island and Brooklyn Railroad Company, Brooklyn, N. Y. The latter part of 1900 found him chief electrician for the Merritt Air Brake Company of New York City, a position which he held until his return West in 1902 to work in the construction and operating departments, and later the contracting department, of the Snoqualmie Falls Power Company, Seattle, Wash. His own Company was established in 1911.

George Frame Ferguson (A'15, M'28) late of Arthur D. Riley and Company, Ltd., Auckland, N. Z., where he held the office of consulting and construction engineer, died there recently. Auckland was Mr. Ferguson's birthplace; there too he received his early education at the so-called "state school" and a course in electrical engineering at the local technical college. In 1906 when 20 years of age he came to the United States and engaged with the Commonwealth Edison Company of Chicago, Ill., remaining there until 1910. Returning to New Zealand, the period from 1911 to 1925 was spent in various hydroelectric undertakings as assistant engineer on the Horo Hora development, the Lake Coleridge works, in the government's hydroelectric department at Tasmania, in charge of high tension design and construction, and with the Southland Power Board on hydroelectric works and distribution. He then returned to Auckland to become manager of the electrical department of Arthur D. Riley and Company, Ltd., representing Ferranti, Ltd., the Telegraph Condenser Company, the Electric Construction Company, and others, carrying out some of the largest contracts in New Zealand, where he was recognized as a capable member of his profession. He was an associate member of the Institution of Electrical Engineering, London, Eng., and a chartered, registered electrical engineer.

H. O. SWOBODA (A'14, M'27) consulting electrical and mechanical engineer at Pittsburgh, Pa., and president and treasurer of H. O. Swoboda, Inc., died June 30, 1932, in the Pennsylvania Hospital of that city after a short illness. Mr. Swoboda was born in Buchholz, Saxony, Germany, February 4, 1870, and received both his primary and early technical training abroad. He was a graduate of the technical university at Darmstadt, Germany. From 1890 to 1892 he was employed by Siemens and Halske, Berlin, Germany, as electrical engineer. He then came to the United States and joined the General Incandescent Arc Light Company of New York, N. Y., as chief electrical engineer and general superintendent. From 1899 to 1902 he held a similar position with The Falcon Electric and Manufacturing Company; from 1902 to 1907 he was employed by the H. O. S. Engineering Company, at Newark, N. J.; dating from 1908 he was for 2 years consulting electrical and mechanical engineer in New York City. In 1910 he joined the Westinghouse Electric and Manufacturing Company at East Pittsburgh, as assistant superintendent, but in 1912, returned to his consulting work, establishing his own office in the city of Pittsburgh. Mr. Swoboda also has been a liberal contributor to scientific and technical literature. He was a registered professional engineer of the state of Pennsylvania, and his memberships included The American Society of Mechanical Engineers, the German technical society Technischer Verein, and the American Society for Steel Treating. His social activities embraced those of the Lincoln Club of Pittsburgh and the Pittsburgh Athletic Association.

RUDOLPH ROSENSTENGEL (A'05) professor of electrical engineering at Gettysburg College, Gettysburg, Pa., died suddenly August 1, 1932, as the result of an embolism. He was 61 years of age and was born in St. Louis, Mo. In 1894 he was graduated from an electrical engineering course at the University of Wisconsin, his earlier education having been acquired in the public schools of Madison, Wis. For 2 years after leaving college, Mr. Rosenstengel was with the Christensen Engineering Company of Milwaukee in the capacity of draftsman; later he also performed 2 years of similar work for N. A. Christensen, also of Milwaukee, still later spending a period of 8 months in the design of several small electric motors in connection with these same interests. He then joined the Brodessor Elevator Manufacturing Company, but a year and a half later severed this connection to identify himself with the Mechanical Appliance Company of Milwaukee. In September of the year 1905 he was chosen as instructor in mechanical engineering at the Michigan Agricultural College.

# Local Meetings

## Future Section Meetings

**Dallas**

September 19—Buffet supper at University Club. REPORT OF SUMMER CONVENTION, by O. S. Hockaday, delegate. TRIBUTE TO VICE-PRESIDENT G. A. MILLS AND DIRECTOR B. D. HULL, by J. B. Thomas. Response by Messrs. Mills and Hull.

**Lehigh Valley**

October 1—Inspection trip through the Reading Railway electrification at Philadelphia.

## Past Section Meetings

**Mexico**

POWER SALES AND THE ENGINEER, by J. M. Zilboorg, Cia Hidroelectrica Guanajuatense. E. F. Lopez, chmn., gave a report of the summer convention held at Cleveland, Ohio. Dinner. July 21. Att. 22.

**Montana**

Business meeting. July 19. Att. 8.

**Niagara Frontier**

Executive committee meeting. July 25. Att. 10.

## Past Branch Meetings

**Drexel Institute**

WIND POWER GENERATING STATIONS, by F. P. States, student. July 20. Att. 9.

FIXED RATIO SYNCHRONOUS FREQUENCY CONVERTERS, by S. I. Croney. August 3. Att. 9.

**University of Louisville**

ATOMIC ENERGY, by R. B. Craig, student, NEW TYPE ELECTRIC CLOCK, by L. B. Bryan, student.

# Employment Notes

## Of the Engineering Societies Employment Service

### Men Available

**Construction**

GRAD. E.E., 29; 5 yr. supervisory construction, design, estimating and field engg. experience on super-pwr. plants and substations; 4 yr. industrial power plant operation, elec. construction and maintenance experience; ry. electrification constr. experience. C-4428.

EXPERIENCED ELECTRICIAN. Col. grad. Wide experience in all branches of elec. installation and service including radio and photoelectricity, desires connection with movie studio. Location and salary no object. D-1309.

E.E. GRAD., 1928, U. of Kansas, 27, married, $2\frac{1}{2}$ yr. technical experience in telephone pole line constr. and maintenance with Am. Tel. & Tel. Co. Six months experience as city engr., 2 yr. experience in highway engg. and reinforced concrete design and construction. Available immediately, location, immaterial. D-1342.

OUTSIDE PLANT ENGR., 27, single, B.S. in E.E. from Sheffield Scientific Sch. in 1927. One yr. experience in testing d-c ry. car lighting equip., 4 yr. design and application of pole line and underground hardware for telephone plant. D-1305.

**Design and Development**

ENGR., 31; 12 yr. Bell system and govt. plant and field experience on sound picture, radio and telephone (manual, dial, repeater and carrier current) systems. Design and devpt. of manual and automatic elec. testing equip. Industrial applications of electron tubes. Available immediately. C-9376.

REFRIGERATION ENGR., 33, married, A.B., E.E., also member Phi Beta Kappa and Sigma Xi. Extensive experience in designing Ranco thermostatic relays, $1\frac{1}{2}$ yr. experience in study and design of humidity and room temperature control apparatus. Desires work with refrigerator mfr., or co. in air-conditioning field. Best of references. D-1310.

DEVPT. AND DESIGN ENGR., B.S., E.E., 35, married; 11 yr. experience elec. construction and design, also devpt., assembly, and testing of oil & gas elec. equip. including engine testing and devpt. of elec. control and engine cooling systems. Can assume full responsibility of devpt. program. Available immediately. Location, immaterial. D-1277.

MECH. AND ELEC. ENGR., inventive, analytical, mature; 30 yr. designing engr. G.E., Crocker Wheeler and Westinghouse. Wide experience in motor control systems and apparatus. Inventions extensively used. Desires devpt. work in same or related fields or as consultant. Salary to suit location and duties. A-2110.

E.E. GRAD., single, 8 yr. switchboard and motor control designing, pricing, specifying, and writing specifications. Qualified designer, estimator, inspector, or genl., resident, operating and consulting engr. Excellent references from 2 elec. mfg. companies. Available immediately. Location, U.S. C-3530.

E.E., 32, col. grad., $8\frac{1}{2}$ yr. diversified experience including test and central station engg. with G.E. Co.; design, construction and system devpt. for a large utility; plant engg. with a large industrial concern; also $1\frac{1}{2}$ yr. small plant power and refrigeration operation and maintenance. C-5727.

DISTRIBUTION, design, or mfg. engr., E.E. grad., 27, married, 6 yr. experience with Westinghouse on distribution, special and small transformer designs. Desires responsible position as transformer design, devpt. or mfg. engr. of elec. engr. for mfg., utility, holding co., or where knowledge of a big company's methods may be used. Available immediately. D-963.

E.E., univ. grad., elec. pwr. experience, both design work and construction and maintenance work, desires position with pwr. or mfg. organization offering permanent or temp. position in office or field. B-1923.

**Executives**

INDUSTRIAL AND CENTRAL STATION ENGR., Cornell grad. Married, 15 yr. practical experience on design, installation and operation of manual and automatic elec. control for industrial and central station application. Available Sept. 1. Capable executive. D-1273.

PLANT ENGR., ASST. EXEC., E.E.-M.E. grad., 20 yr. broad experience in and with mech. trades on construction and plant maintenance; in modern design, manufacture and installation of equip.; design and layout of plant. Special training and experience in metallurgy, concrete, elec. arc welding, building constr., specifications, business mgmt., sales. C-4519.

EXEC. ASST. available, E.E. grad., 37; 12 yr. utility experience. Appraisal work of power plants, substations, transmission and distribution systems, rate investigations covering industrial service, residential and commercial, cost studies, statistical research, operation in plant, equip. and lines. G.E. test course. B-9782.

INDUSTRIAL PLANT ELEC. EFFICIENCY EXPERT, 36, with steam engg. and elec. engg. diploma and 12 yr. industrial plant experience, desires position with opportunity. Will go anywhere. B-7004.

ELEC. AND CHEM. ENGR., experienced in tel. and tel. communication including devpt., mfg., and operation, 37, married. Can fill any suitable position requiring initiative, wide experience, and a large acquaintanceship in the communication industry. C-1971.

E.E. GRAD., 38; 17 yr. experience, construction, installation, maintenance, inspections, tests, pwr. plants and substations, distribution (high and low tension), 1 yr. operating, familiar with So. Am., speaks several languages. Available at once, home or abroad. Best of references. C-2021.

E.E. GRAD., 46, married. G.E. test followed by 20 yr. experience in transformer design and manufacture with the large companies. Desires connection with elec. mfr. or pwr. co. Available on short notice. C-8806.

E.E., M.I.T.; 1921; Columbia Univ.; 32, married. Engr., consultant, editor, tech. sales rep. Broad exper., U.S., Canada, communication apparatus, circuits; telephone, telegraph; voice, carrier, radio frequency; amplifiers, sound pictures, program transmission. Built, directed electro-acoustic testing lab. Experience, employment; patent consideration, court testimony; magazine, newspaper publishing; lecturing; publicity. Prefer New York. D-1315.

E.E., B.S. in E.E., Iowa St. Col. 1929; '32, single, worked way through col. 3 yr. group leader, Westinghouse transformer test, including power, distr.; and instrument transformers, a-c welding outfits, special apparatus. Liberal shop experience. Interested, exec. position, supervision, design, and constr.; inspection and testing. References. Location immaterial. Available immediately. D-1081.

E.E., univ. grad., pwr. experience, desires position with pwr. or mfg. co. Devpt. work preferred, but not essential. B-1923.

E.E., 20 yr. experience in design, maintenance, and construction of central and substations; equip. of buildings and industrial plants, desires a connection with utility or factory. Specialized work, in protective circuits, metering problems; automatic elec. control of conveyors, substations, condensers, and combustion systems for boilers. B-7290.

ENGR.-ACCOUNTANT. E. E. deg., 1912, special study in accounting, exec. experience, 10 yr. with pub. serv. commission and 7 yr. mgmt. corp. making appraisals, audits, rate studies, and investigations all classes utilities both U.S. and Latin America. Available soon. C-2569.

**Inspection**

GRAD. E.E., 1927, single, 3 yr. experience as inspection engr. and supervisor; 1 yr. of meter testing. Location in the East. Available immediately. C-3213.

**Instruction**

M.E.; M.S., 26, single. Four yr. experience in telephone work. Desires teaching or engg. work of any nature except sales. Available immediately. Location, immaterial. D-1225.

GRAD. E.E., 7 yr. teaching, 18 yr. practical experience. Last 12 yr. in mechanical lines; steam, gas, air, and water engg., ore and alkali plants, handling, conveying, and process equp. Taught heat pwr. engg. at Oregon St. Col. and elec. lab. at Beaune, France. Location, immaterial. A-3651.

E.E. GRAD., 1930, 27, single. Fourteen months G.E. test. Five months assignment in G.E. research lab. Experience also includes teaching E.E. subjects for 7 months. Desires position as instructor in E.E. subjects or physics with opportunity of taking grad. work. D-136.

PROFESSOR, B.S. (E.E.), M.S., and E.E. deg., Colorado and Cornell, 38, 9 yr. experience teaching elec. engg. subjects and engg. physics, 9 yr. practical experience in varied fields. Available for Sept. D-1351.

INSTRUCTOR, elec. lab. and trade training. grad. Lowell Inst. auspices M.I.T., elec. and industrial mgmt. courses, Mass. and Conn. teacher's certificate, 44, married. Twenty yr. elec. utility operating experience, maintenance electrician, contracting, secy. Elec. Lines Club, chairman meeting and papers committee, Mass. Assn. Municipal Elec. Inspectors. C-8411.

PHYSICIST, 49, married., Ph.D. Seven yr. univ. teaching experience, Yale, U. of Ill.; 1 yr. study, Rutherford, England. Fifteen yr. experience, directing, carrying on research in heat transmission and phases elec. and mech. lines 2 large industrial concerns. Present position being discontinued. Desires position of responsibility, univ. teaching or in industrial research. D-1366.

E.E. GRAD., 26, single, excellent physical condition. One yr. experience installation, testing telephone exchange equip. Three yr. teaching pub. sch. Grad. small bus. col. Considerable training, experience, selling. Not afraid of hard work. Interested in position requiring engg. knowledge or teaching experience. Excellent references. Correspondence invited. Location, immaterial. Available immediately. D-1076.

E.E., married, good health and strong physique, M.S. in E.E. 1932 with thesis on mercury tube voltage regulator, 3 yr. teaching engg. drawing and descriptive geometry in large univ., clever in adjustment and repair of mech. and elec. devices, machinist experience. Westinghouse grad. student. Prefers teaching position, but anything considered. D-445.

MECH.-ELEC. ENGR., 32, 4 yr. Cornell design instructor; 5 yr. Allis-Chalmers design; liberal shop experience; 5 yr. cooperative apprenticeship. Will consider anything, anywhere, now available. Salary open. D-122.

**Junior Engineers**

E.E. GRAD., U. of Pittsburgh, 1932, single, 27. Five yr. various elec. experience including wiring, radio, substation operation and maintenance, experience on oil circuit breakers, and several months' experience testing pwr. relays. Prefers position with utility. D-1249.

GRAD. E.E., 29, single. Desires connection with constr., utility, mfg. or holding co. Five yr. experience designing both a-c and d-c motors with large elec. mfg. co. Aggressive and capable of assuming responsibility. Excellent references. Available immediately. D-944.

RECENT RENSSELAER POLY. INST. GRAD., E.E., 1932; Sigma Xi; single; 22. Summer experience in engg. and standardization dept. of large mfg. concern. Desires work in any engg. field. Salary and location secondary. Available immediately. D-1296.

B.S. in E.E., 1931, Armour Tech., 23, single, experience, 6 mos. telephone, 3 mos. G.E. Co. student, 7 mos. utility co. student. Speaks German well, wants work. Salary secondary. Location, immaterial. D-1072.

GRAD. E.E., B.S., A.B. from a foreign univ., desires position with a mfg. co. or a utility in transmission, distribution or testing lab. or elec. ry. Available on short notice. Location, immaterial. D-1110.

E.E. GRAD., '32. Married, 24. Experience includes 6 months asst. radio engr. at broadcast station, amateur 3 yr., 6 months auto. mech. Holds radio broadcast and amateur licenses. Very good references. D-1360.

E.E. GRAD., 1932, Mississippi St. Col., single, 30, excellent health. Two yr. marine electrician, U.S. Navy; 2 yr. engr. and operator local lt. and heat plant, Union Univ., Jackson, Tenn.; illumination experience. Desires position with future. Available immediately—anywhere, South or West preferable. D-1269.

B.S. in E.E. 1932. Ohio Univ., 22, single. Desires position with utility or mfg. concern. Wiring and repair experience. Particularly interested in work with motors and generators. Available immediately. Location, immaterial. D-1280.

B.S. in E.E., 1931 grad., single, 24, desires position in elec. engg. preferably teaching or research. Two summers' experience with elec. contracting co. Was grad. asst. at col. this yr. High scholastic record. References. Salary and location secondary. Available immediately. D-1259.

E.E., 27, single, available Nov. for responsible position abroad, British West Indies preferred. Eight yr. practical experience in large Canadian repair shop handling all types pwr. equip. Three yr. executive and sales. Able to take charge repair dept. industrial concern or pwr. co. Knowledge of industrial engg. Excellent references. C-8336.

B.S. IN E.E. 1932, 23, single. Five yr. cooperative course, 18 mos. experience with telephone and pwr. co. Winner first award South Eastern A.I.E.E. convention. Salary immaterial at start Available at once, location, U.S. D-1304.

B.S. IN E.E., New York Univ., 1932, single, 21, member Tau Beta Pi. One summer's experience in test dept. United Electric Lt. & Pwr. Co. Industrious, intelligent worker who can take and give orders in right manner. Location, salary immaterial factors. C-9434.

E.E. GRAD., '28, B.S. '27. Four yr. with large mfg. concern. Special training in engg. fundamentals (elec. and mech.) as preparation for devpt. work. Desires position with mfg. concern, utility, teaching or as asst. to consultant. D-1290.

E.E. GRAD., 1931, Mid-West univ., 25, single, 2 yr. experience with elec. contracting and constr. co. Desires position in the illuminating field. Location, immaterial and available immediately. D-1365.

E.E. GRAD., Purdue, 1930. Single, 24. Two yr. communication experience and training with Am. Tel & Tel. Co., including outside line and cable construction; test room operation, carrier systems, etc., also Morse telegraphy. Not afraid of hard work. References gladly furnished. Available immediately to go anywhere. D-1075.

E.E. GRAD., 29, married. Five yr. with Western Elec. Co. Experience most valuable for communication engg., but also desires work in research lab. or any engg. field. Good scholastic record. Available anywhere on short notice but East preferred. D-1323.

M.S. in E.E., 1932, 22, single. Technical experience with X-ray and glow discharge tubes. Desires position in teaching or engg. field. Salary and location immaterial. Available after Sept. 10. D-1375.

B.S. in E.E., 1932. Married. Some experience in surveying. Location, immaterial. Prefer work in elec. field but will consider anything. Available immediately. D-1373.

B.S. in E.E., 1932, 22, single. Good references, desires engg. work with future. Location, immaterial. Available at once. D-1374.

**Maintenance & Operation**

FOREMAN, 37, single, desire foreign or domestic connection involving constr., operation or maintenance (elec.) or pwr. houses, substations or industrial installations of all voltages and capacities. Has had 3½ yr. experience in Latin America with Am. holding co. Available now. Location, immaterial. D-1343-328-C-1-San Francisco.

ELEC. MAINTENANCE ENGR.-operator-elec. foreman-inspector-electrician-tech. grad., 30. Twelve yr. experience. All types industrial and mining equipment. Construction and operation of hydroelectric, steam, pwr. plant, outdoor switching stations; transmission lines distribution and telephone systems; elec. ry. Seven yr. Latin America. References. Knowledge Spanish, Portuguese. D-1353.

## ENGINEERING SOCIETIES EMPLOYMENT SERVICE

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MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

**Men Available.**—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

**Opportunities.**—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

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**Answers to Announcements.**—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

**Patents**

PATENT ENGR., comprehensive experience including preparation patent applications, analysis patents for essential scope, tests marketed products to ascertain infringement, test and testimony in litigation. Familiar, elec., acoustic, wire communication, radio fields. Qualified by basic preparation Ph.D. in physics to do effective work in other engg. branches. Can conduct research if desired. C-4919.

**Research**

RESEARCH ENGR., B.S. in E.E., Pennsylvania St. Col., 1930; 1½ yr. experience as statistician-research engr. on industrial and marketing surveys. Can speak Spanish fluently. C-7551.

INVENTOR, just completed invention of office machine of cash register type desires income. Exceptionally qualified for inventive, design or research work and has widely varied experience including automobiles, elec. equip., and utilities. Education, E.E. and business administration. G.E. test. No better or harder worker can be found. Any location. C-9820.

E.E., M.S. '29, Ph.D., Calif. Inst. Tech. '32. Research work dealt with measurement lighting currents, use high and low frequencies and surges in dehydration of crude oil emulsions, and cracking of gasolines. Two yr. experience, electrician, pwr. plant test engr. Desires position, where experience, and training will be useful. Single, 28. D-1350.

E.E. GRAD., '23 Sc.M., M.I.T. and Harvard '28; Sc.D. M.I.T. June '32; 38, single; 9 yr. practical experience, pwr.-and-communication engg. Two yr. testing course. Speaks Swedish, English, German; reading knowledge French. Desires position preferably in line of communication engg. Available. Location, immaterial. D-747.

PUB. UTILITY RESEARCH; U. of Ill. grad., 36, married. Twelve yr. experience consulting field charge of transit and street traffic operating surveys, pwr. and other utility rate, regulation, franchise, valuation, and financing investigations, most principal eastern, mid-west and southern cities. Open to either permanent or good temporary assignment. B-446.

MEDICALLY INCLINED 1930 E.E. grad., industrial experience, desires elec. work, hospital, medical school or research lab. where experimental or practical work is being done in applied elec. Studied electrotherapeutics past year. Salary secondary to opportunity to study this special application of electricity. Intends taking academic work in this field. C-9497.

E.E. GRAD., Bucknell 1928. Single, 26. One yr. experience research dept., of large engg. corp., 3 yr. experience and training with Am. Tel & Tel. Co. including outside line and cable constr. and testing methods; also familiar test room operation and methods. Excellent references. Available immediately. Location, immaterial. C-4528.

**Sales**

SALES ENGR., E.E. deg., 30, single, 3½ yr. high grade sales experience selling industrials and educational institutions, contacting distributors branches, etc. Good correspondent. 1½ yr. engg. dept. large utility. 1½ yr. elec. testing lab. Some elec. contracting. Desires position of promise with mfg. concern. Mid-West preferred, not essential. Available one month. D-1344.

ASSOC. A.I.E.E., single, 26, E.E. Grad. J. H. U. Experience: 6 mos. switchgear testing; 3½ yr. as motor control engr., including shop, engg., and sales work; 6 mos. as jobbers' salesman. Familiar with industrial control design, application, and estimating. Desires any engg. position with opportunity. East preferred, not essential. D-1368.

GRAD. E.E., 1926, Columbia, 29, married. Practical experience with pwr. and telephone companies. One yr. lab. asst. in elec. classes and 4 yr. instructor in evening classes in col. mathematics. Engg. sales experience. C-9308.

E.E. GRAD., 29, single. Seven yr. with elec. utilities covering distribution planning, operation, customer contacts, etc. Substation design, equip. recommendations, voltage studies, relay setting. Eighteen months' experience changing system from 30 to 60 cycles, involving industrial electrification; covering uses of electricity. Can write reports. Suited for pwr. sales work. Available immediately. C-5960.

B.S. IN E.E., Professional Engr., N. J., 34, married. Storage battery, automotive elec. sales and service, 5 yr. heat and sound insulation sales engg. contacting architects, engineers, job supervising, 4 yr. steel corp. sales engr. contacting architects, engr., New York, New Jersey, 3 yr. inventive ability and experience. C-75.

NATURAL GAS HEATING, VENTILATING, AND APPLIANCE ENGR., 27, grad. B.S. in E.E. Two yr. experience in design, installation, and maintenance of gas heating plants. Formerly on sales engg. staff of western utility. Available immediately. C-9525.

SALES ENGR., single, grad. E.E.; 7 yr. experience selling elec. equip. (motors, generators, etc.) to industrial plants located in the East and Mid-West territories and 13 yr. connection with large utilities in industrial sales work and as supervisor of pwr. sales dept. C-5546.

GRAD. ENGR., 25, 2 yr. practical work, research and testing. Capable of speaking, reading and writing Spanish fluently. Available at once, willing to travel if necessary. Class of 1930. Willing to study under sales engr. as applicant has 2 yr. selling experience. C-9002.

# Membership

## Recommended for Transfer

The Board of Examiners, at its meeting of July 27, 1932, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the acting national secretary.

**To Grade of Fellow**

Dates, Henry B., prof. of e. e., Case Sch. of Ap. Sci., Cleveland.
Dows, Chester L., head elec. and photometric measurements, Genl. Elec. Co., Cleveland.
Enfield, Wm. L., mgr., Incandescent Lamp Dept., Genl. Elec. Co., Cleveland.
Jansky, Cyril M., prof. of e. e., Univ. of Wisconsin, Madison.
Lincoln, John C., chmn. of board, Lincoln Elec. Co., Cleveland.
McMillan, Fred O., research prof. of e. e., Oregon State Col., Corvallis.

**To Grade of Member**

Berry, Henry P., preliminary plans engr., Chesapeake & Potomac Tel. Co., Charleston, W. Va.
Bolsterli, Arthur A., elec. engr., Safety Car Heating & Lighting Co., New Haven, Conn.
Carville, Ellsworth M., small motor design engr., Westinghouse E. & M. Co., Springfield, Mass.
Charest, J. C., supt. of distribution, Pa. Pwr. & Lt. Co., Hazleton.
Clark, Sam W., engr. and supt. of pwr. plant construction, Calle Gante No. 15, Mexico, D. F.
Congleton, Ray T., proprietor, Congleton Engg. Co., Dayton, O.
Crymble, Alfred C., pres., Crymble Elec. Co., Inc., Bristol, Va.
Del'Homme, Laurence, asst. engr., Houston Ltg. & Pwr. Co., Texas
Eide, Randolph, pres., Ohio Bell Tel. Co., Cleveland.
Frazier, Richard H., asst. prof. of e. e., Mass. Inst. of Tech., Cambridge.
Gill, Peter Clark, supt. of trans. and distribution, B. C. Elec. Ry. Co., Vancouver, B. C.
Harrington, Charles A., e. e. dept., Cleveland Elec. Ill. Co., Ohio.
Hattingh, Johannes T., tech. asst. to chmn. of electricity supply commission, Johannesburg, S. Africa.
Hibshman, Nelson S., asst. prof. of e. e., Lehigh Univ., Bethlehem, Pa.
Hill, Owen E., supervising devpmt. engr., Western Elec. Co., Inc., N. Y. City.
Hover, Ernest W., design engr., Central Hudson Gas & Elec. Corp., Poughkeepsie, N. Y.
Jansky, C. Moreau, Jr., consulting radio engr., Jansky & Bailey, Washington, D. C.
Keiffer, Lawrence R., elec. engr., Genl. Elec. Co., Cleveland, O.
Kubiak, Henry J., instructor in e. e., Univ. of Wisconsin, Madison.
Mason, H. Russell, prof. of e. e., Southwestern Louisiana Inst., Lafayette.
Payne, John H., elec. engr., East Orange, N. J.
Pearson, Harold E., switchgear commercial engr., Genl. Elec. Co., Phila., Pa.
Porter, Vance G., dist. mgr., Central Pwr. & Lt. Co., Bay City, Texas.
Ranson, Richard R., elec. engr., Cutler Hammer, Inc., Milwaukee, Wis.
Schnautz, Wm. J., outside plant engr., N. Y. Tel. Co., Buffalo, N. Y.
Spring, Ernest W., research engr., Detroit Edison Co., Mich.
Staehle, Daniel, Jr., elec. engr., Frank Adam Elec. Co., St. Louis, Mo.
Stine, Wilmer E., research and welding engr., Lincoln Elec. Co., Cleveland, O.
Wilson, Archibald F., asst. vice-pres., Ohio Bell Tel. Co., Cleveland.
Youngstrom, N. C., member tech. staff, Bell Tel. Labs., Inc., New York.

## Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the acting national secretary before Sept. 30, 1932.

Berthold, R. V., Assonet Beach, Mass.
Busby, T. A., The Commonwealth & Southern Corp., Birmingham, Ala.
Hanson, V. A., (Member) Mechanical Pwr. Engg. Associates, Bklyn., N. Y.
Hatto, S. G., Shell Oil Co., Seattle, Wash.
Izzi, V. A., Bd. of Transportation, City of N. Y., N. Y.
Kendall, Ralph M. (Member), Amer. Tel. & Tel. Co., 195 Bway., N. Y. City.
Miller, H. E., (Member) Westinghouse Elec. & Mfg. Co., Newark, N. J.
Mitchell, S. R., 1840 Lincoln St., Denver, Colo.
Niemann, A. W., Bell Tel. Lab., Inc., N. Y. City
Olsen, W. O., 1054 52nd St., Bklyn., N. Y.
Spiegel, W. F., Ry. Express Agency, Inc., Hoboken, N. J.
Stone, M., Westinghouse Elec. & Mfg. Co., Pittsburgh, Pa.
Strothman, R. A., 7 Laurel Ave., Summit, N. J.
Thicke, J. E., Aluminum Co. of Canada, Montreal, Quebec.
Turner, C. G., Kansas City Pwr. & Lt. Co., Mo.
15 Domestic

### Foreign

Alizo C., Antonio, Cia. Anoma, Planta Elect. de Valera, Est. Trujillo, Venezuela, S. A.
Beljabsky, A. G., (Member) North-Caucas Inst. of Energetics, Novocherkassk, U.S.S.R.
Bryant, A., Kenya & Uganda Govts., Nairobi, Kenya Colony, E. Africa.
Chan, S., 33 Wan Tsai Rd., Hong Kong, China.
Foulsum, W. C., 16 Bondoran Parade, Mont Albert, Melbourne, Australia.
Kesavan, V. K., Pwr. Station Kottayam, Travancore, So. India.
Rozario, J. F. T., Pub. Wks. Dept., Madras Govt., Madras, India.
Thampan, K. C., Pykara Construction Wks., Glen Morgan P. O., The Nilgiris, So. India.
Verma, R. P., Gaya Engg. & Elec. Pwr. Sup. Co., Ltd., Gaya, India.
9 Foreign

# Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Adams, Albert J., 950—18th Ave., Honolulu, T. H.
Blugerman, L. N., 227 N. 18th St., Phila., Pa.
Callen, R. J., Brunswick Recording Lab., 709—7th Ave., N. Y. City.
Cooper, Lamar S., 1936 Dallas St., Phila., Pa.
Dalas, F. L., Boulder City, Nev.
Deney, Roger W., 685 Sumner-Atlantic Ave., Forest Hills Boro, Pittsburgh, Pa.
Diamond, Harvey, Avenida Concepcion 105, Providencia, Santiago de Chile, S. Am.
Gooding, Chas. C., 1414 K St., Sacramento, Calif.
Keiser, Morris, 1025 King St., Alexandria, Va.
Morita, Kadzuo, c/o Chosen Hydro-Elec. Co., Kankyo-Nando, Korea, Japan.
Neander, M., 182 Pravy Bereg Nevy Kv. 51, Leningrad, U.S.S.R.
Nichols, E. D., 536 W. 3rd St., Erie, Pa.
Olsson, Oscar G., 361 Mulberry St., Williamsport, Pa.
Pearson, Ernest, 209 Brewster Rd., Scarsdale, N. Y.
Schroeder, G., Krivokolenni Pereulok No. 11-16, Moscow, U.S.S.R.

# Engineering Literature

## New Books
### in the Societies Library

Among the new books received at the Engineering Societies Library, New York, during July are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

PLANNING FOR RESIDENTIAL DISTRICTS. Ed. by J. M. Gries and J. Ford. President's Conference on Home Building and Home Ownership, Washington, D. C., 1932. 227 p., illus., cloth, $1.00.—The final reports of 4 committees of the President's Conference on Home Building and Home Ownership; viz., city planning and zoning, subdivision layout, utilities for houses, and landscape planning and planting. This is a compact presentation of principles and practises, most interesting to planning commissions, public officials, civic improvement associations, and home owners. The various committees included well-known specialists in each field, and their findings are the result of wide experience.

REFRIGERATING DATA BOOK AND CATALOG. 1st ed., 1932–1933. Am. Soc. of Refrig. Engrs., N. Y., 1932. 480 p., 120 p., cat. information, illus., 10x6 in., leather, $3.50.—The basic data of refrigeration engineering are brought together in this volume which will be welcomed as a convenient encyclopedia of current practise. The various topics have been treated by specialists with the assistance of an advisory committee appointed by the society. Principles, equipment, and uses all are discussed.

STRESSES IN FRAMED STRUCTURES. Pt. 1. Design of Steel Mill Bldgs. By M. S. Ketchum. N. Y. & Lond., McGraw-Hill, 1932. 217 p., 9x6 in., cloth, $2.50.—This book covers the calculation of the stresses in simple beams, trusses, portals, the transverse bent and the 3-hinged arch, and is intended as a beginning course in the subject; 40 problems which cover the calculation of stresses in practically all types of simple roof and bridge trusses, bents and portals, are solved. Both algebraic and graphic methods of calculation are given. Reprinted from the author's "Design of Steel Mill Buildings."

SUPERHEAT ENGINEERING DATA. 7th rev. ed. N. Y. & Chic., Superheater Co., 1932. 253 p., illus., 7x5 in., leather, $1.00.—A useful collection of rules, formulas, numerical data, and other information frequently wanted by steam engineers and power plant operatives interested in superheating. In addition to the general data, the products of the publisher are described and their use illustrated by a variety of typical installations.

TEXTBOOK OF ELECTRICAL ENGINEERING, 1931. London, H. M. S. O., may be purchased in U.S. from British Library of Information, N. Y. 545 p., illus., 9x6 in., cloth, $2.88.—Prepared for engineer officers of the British army in its electrical service. The generation, transmission, distribution, and utilization of electricity are discussed in a thoroughly practical way, with special reference to the needs of military encampments, barracks, etc. The entire range of electrical work is covered in a severely practical manner. A book which seems well adapted for its purpose.

THEORY OF DIELECTRICS. By A. Schwaiger, transl. by R. W. Sorenson. N. Y., John Wiley & Sons, 1932. 480 p., illus., 9x6 in., cloth, $6.50.—This translation of the second edition of "Elektrische Festigkeitslehre" is intended to fill the needs of engineers and students in search of a comprehensive, readily understandable presentation of the laws of dielectrics. The book is divided into 3 parts, devoted to puncture, arcover, and the practical applications of high-voltage engineering. In addition to reviewing the work of others, considerable original work is included. Includes a list of references to other German publications.

UNIT PROCESSES AND PRINCIPLES OF CHEMICAL ENGINEERING. By J. C. Olsen. N. Y., D. Van Nostrand Co., 1932. 558 p., illus. 9x6 in., cloth, $5.00.—In preparing this textbook, the author has endeavored to present the fundamental chemical and physical principles determining the course of any given chemical reaction, the so-called unit processes which must be utilized in carrying it out upon a commercial scale, and the combination of these processes in proper sequence and coordination. The processes selected for treatment are the most important and most fully developed ones. Each chapter is by a specialist. An excellent introduction to chemical engineering.

WESTERN AND ATLANTIC R. R. OF THE STATE OF GEORGIA. Compiled by J. H. Johnston. Atlanta, Ga., Pub. Serv. Com., 1932. 364 p., illus., 9x6 in., leather, $5.00.—This volume traces the history of a state-owned railroad from its inception to the present day and describes its varying fortunes under state operation and in the hands of successive lessees. The volume is based upon official records and primarily is intended to supply legislators of Georgia with a convenient record of essential facts. It is also an interesting addition to the history of American railroads.

ALLGEMEINE UND TECHNISCHE ELEKTROMETALLURGIE. By R. Müller. Vienna, J. Springer, 1932. 580 p., illus., 9x6 in., cloth, 32.50 rm.—This work is to provide in one volume a concise yet thorough treatise on electrometallurgy and the electrochemical properties of metals, emphasizing commercial methods of production, but noting others briefly. Admirable as a good survey of current methods, with abundant references to literature and important patents.

ATM ARCHIV FÜR TECHNISCHES MESSEN. Lieferungen 4–12, Nov. 1931–June 1932. München und Berlin, R. Oldenbourg. Illus., 12x9 in., paper, 1.50 rm. each.—A compendium of measuring instruments and methods, intended to cover in 5 vols. the whole tech. measurement field. Parts issued monthly and sold singly, each with a 2- to 4-p. review of some dozen instruments or methods and giving ref. to orig. sources. Classified by the Decimal System and a special system, and arranged for loose-leaf binding.

AUSGEWÄHLTE SCHWEISSKONSTRUKTIONEN, Bd. 3. Rohrleitungs- und Behälterbau. By Holler and A. D. Fink. Berlin, VDI-Verlag, 1932. 88 p., illus., 12x9 in., cloth, 12.50 rm.—A set of 88 plates on the application of modern welding for container and pipe line construction. They present a wide variety of apparatus selected to show the advantages of welded equipment for chemical factories, steam plants, etc. Explanations in English.

ÉLECTRICITÉ ET MAGNÉTISME (MEMENTO D' ÉLECTROTECHNIQUE, v. 1). By A. Curchod. Paris, Dunod, 1932. 526 p., illus., 8x5 in., cloth, 99 frs.—Latest addition to handbooks on elec. engg. by the editor of "Revue Générale de l'Électricité," and written to provide the practising engr. with a concise and accurate ref. work similar to the well-known Am. and German handbooks. The first of 4 v., it discusses math., units, fundamental laws of electricity and magnetism, measurements and matls. Includes several bibliographies.

ELEKTRISCHE INDUSTRIEÖFEN FÜR WEITERVERARBEITUNG. By V. Paschkis. Berlin, J. Springer, 1932. 305 p., illus., 9x6 in., cloth, 31,50 rm.—Intended to present a systematic, comprehensive work on the elec. furnace to meet the needs of designers and users. The principles of design, methods of regulation, matls., and the economics of elec. furnaces are considered. Various constructions and their elements are treated at length. Limited to resistance furnaces, explicit directions for design being given.

ELEKTRISCHES KOCHEN. By F. Mörtzsch. Berlin, J. Springer, 1932. 178 p., illus., 10x7 in., cloth, 8.50 rm.—A report of semi-popular style, based upon a series of studies made by elec. plants and elec. mfrs. of Germany, to promote the genl. introduction of elec. cooking and wtr-htg. apparatus for homes, hotels, and institutions. Includes design of efficient apparatus and the finding of proper rates, therefor; also compares elec. heat with other kinds.

GRAPHS FOR ENGINEERS AND ARCHITECTS. By D. H. Lee. Lond., E. & F. N. Spon, Ltd.; N. Y., Spon & Chamberlain, 1932. 88 p., illus., 11x9 in., leath., $2.00.—These graphs treat of a variety of matters in building design and construction and are intended for quick design and checking of calculations. Those for determining safe loads on brick piers and steel, timber, and reinforced-concrete beams, stanchion stresses, wind stresses, panel loads, floor constructions, and similar problems are given and discussed.

INDUSTRIAL MANAGEMENT. By E. C. Robbins and F. E. Folts. N. Y. & Lond., McGraw-Hill, 1932. 757 p., illus., 9x6 in., cloth, $5.00.—Here the "case system" is applied to a beginner's course in industrial management, with 117 cases given to convey concepts underlying modern management; i. e., specialization, diversification, and integration; also their application to managerial control of raw materials, labor, plant, and equipment. To train the student to realize significant facts in managerial problems and to use them basically.

INTRODUCTORY COURSE IN PHYSICAL CHEMISTRY. By W. H. Rodebush and E. K. Rodebush. N. Y., D. Van Nostrand Co., 1932. 421 p., illus., 9x6 in., cloth, $3.75.—A textbook based upon a Univ. of Ill. course; for college Juniors with training in chemistry, physics, and calculus. Fundamental principles are given in a clear, precise manner. The course is designed for a year and presents the material usually included in such courses but with some novel methods and arrangement.

PHYSIKALISCHES HANDWÖRTERBUCH. By A. Berliner and K. Scheel. 2 ed. Berlin, J. Springer, 1932. 1428 p., illus., 11x8 in., paper, 96 rm.—Besides defining terms and concepts of classic and modern physics, this book gives much on astronomy, mathematics, geodesy, geology, physical chemistry, engineering, and other related subjects. It is encyclopedic, with articles signed, and frequent ref. to other information given. Invaluable, especially for those not versed in physics, and for physicists desiring quick orientation in subjects outside their field. The new edition is half again as large as the former.

PRINCIPLES OF REFRIGERATION. By W. H. Motz. 3 ed. Chicago, Nickerson & Collins Co., 1932. 1019 p., illus., 9x6 in., cloth, $7.50.—Giving fundamentals in the operation of refrigerating machinery; the properties of the usual media; design, construction, and operation of the apparatus; also important applications of refrigeration set forth practically and non-mathematically. Adopted by the Natl. Assn. of Practical Refrigeration Engrs. for its national lecture courses. Rewritten and considerably enlarged.

RECENT ADVANCES IN TOWN PLANNING. By T. Adams and others. N. Y., Macmillan Co., 1932. 400 p., illus., 10x7 in., cloth, 25s.—Describing recent advances and tendencies in town planning in its 3 phases of law, practise, and design in an effort toward a comprehensive survey. The point of view is British in its aspect with conditions in Great Britain given special consideration. There is, however, much upon conditions in America and other countries. A book of interest to American town planners. A useful bibliography of books and reports is included.

TEXTBOOK OF METALLURGICAL PROBLEMS. By A. Butts. N. Y. and Lond., McGraw-Hill, 1932. 425 p., illus., 9x6 in., cloth, $4.00.—Resembling "Metallurgical Calculations" by the late Prof. J. W. Richards and somewhat supplementing it, this book extends facts into certain channels also giving new and more accurate numerical data. Its main purpose is to supply a textbook with a graded treatment of the subject, suited for use in engineering courses rather than a handbook for practising engineers. A thorough introduction to problems arising in metallurgy and methods of solving them.

THOMAS' REGISTER OF AMERICAN MANUFACTURERS. 22nd ed., 1931–32. N. Y., Thomas Pub. Co., illus., 12x9 in., cloth, $15.00.—Listing, under products and firm names, Am. mfrs. and primary sources of supply. Trade names, brands, banks, boards of trade, and other commercial organizations, and trade papers are listed. Unequalled in comprehensiveness and completeness.

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### American Committee on Marking of Obstructions to Air Navigation

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I. E. Moultrop
Farley Osgood
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**Nat. Safety Council, A.S.S.E.—Engg. Section**
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**Radio Advisory Com., Bur. of Standards**
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**Welded Rail Joints, Committee on**
D. D. Ewing

## Geographical District Executive Committees

| District | Chairman (Vice-President, A.I.E.E.) | Secretary (District Secretary) |
|---|---|---|
| No. 1—North Eastern | J. Allen Johnson, 302 Electric Building, Buffalo, N. Y. | A. C. Stevens, General Electric Co., Schenectady, N. Y. |
| No. 2—Middle Eastern | W. B. Kouwenhoven, Johns Hopkins University, Baltimore, Md. | G. S. Diehl, Pennsylvania Water & Power Co., 1611 Lexington Building, Baltimore, Md. |
| No. 3—New York City | E. B. Meyer, 80 Park Place, Newark, N. J. | C. R. Jones, Westinghouse E. & M. Co., 150 Broadway, New York, N. Y. |
| No. 4—Southern | W. E. Freeman, University of Kentucky, Lexington, Ky. | E. A. Bureau, University of Kentucky, Lexington, Ky. |
| No. 5—Great Lakes | K. A. Auty, Commonwealth Edison Co., 72 West Adams St., Chicago, Ill. | A. G. Dewars, No. States Pr. Co., 15 S. 15th St., Minneapolis, Minn. |
| No. 6—North Central | P. H. Patton, Northwestern Bell Tel. Co., Telephone Building, Omaha, Neb. | M. S. Coover, University of Colorado, Boulder, Colo. |
| No. 7—South West | G. A. Mills, Michigan Gas & Electric Co., Lansing, Mich. | R. W. Warner, University of Kansas, Lawrence, Kans. |
| No. 8—Pacific | A. W. Copley, Westinghouse Elec. & Mfg. Co., 1 Montgomery St., San Francisco, Calif. | C. E. Baugh, 245 Market St., San Francisco, Calif. |
| No. 9—North West | C. R. Higson, Utah Power & Light Co., Kearns Building, Salt Lake City, Utah | Paul Ransom, Utah Apex Mining Co., Bingham Canyon, Utah |
| No. 10—Canada | L. B. Chubbuck, Canadian Westinghouse Co., Hamilton, Ont. | W. L. Amos, Hydro-Elec. Pr. Comm., 190 University Ave., Toronto, Ont. |

Note: Each district executive committee includes the chairmen and secretaries of all Sections within the district and the chairman of the district committee on student activities.

## Local Sections of the Institute

| Name | District | Chairman | Secretary | Secretary's Address |
|---|---|---|---|---|
| Akron | 2 | A. P. Regal | W. H. Tucker | 716 S. Main St., No. Canton, Ohio |
| Atlanta | 4 | O. O. Rae | J. H. Persons | General Electric Co., Atlanta, Ga. |
| Baltimore | 2 | J. Wells | J. L. D. Speer | Chesapeake & Potomac Tel. Co., Baltimore, Md. |
| Birmingham | 4 | | | |
| Boston | 1 | F. D. Hallock | G. J. Crowdes | Simplex Wire & Cable Co., 66 Sidney St., Cambridge, Mass. |
| Chicago | 5 | L. R. Mapes | D. L. Smith | Chicago Rapid Transit Co., Chicago, Ill. |
| Cincinnati | 2 | L. O. Dorfman | A. C. Burroway | Cincinnati & Sub. Bell Tel. Co., Cincinnati, Ohio |
| Cleveland | 2 | J. M. Smith | S. B. Taylor | Reliance Elec. & Engg. Co., Cleveland, Ohio |
| Columbus | 2 | K. Y. Tang | H. L. Willson | General Electric Co., Columbus, Ohio |
| Connecticut | 1 | C. J. Daly | W. B. Hall | Yale University, New Haven, Conn. |
| Dallas | 7 | H. K. Handley | W. B. Folline | General Electric Co., Dallas, Texas |
| Denver | 6 | W. D. Hardaway | N. R. Love | 807 Tramway Bldg., Denver, Colo. |
| Detroit-Ann Arbor | 5 | O. E. Hauser | R. Foulkrod | Michigan Bell Tel. Co., Detroit, Mich. |
| Erie | 2 | J. C. Milling | C. V. Roberts | Erie Lighting Co., Erie, Pa. |
| Florida | 4 | Joseph Weil | R. P. Smith | P. O. Box 2574, Jacksonville, Fla. |
| Fort Wayne | 5 | B. A. Case | C. M. Summers | General Electric Co., Fort Wayne, Inc. |
| Houston | 7 | J. B. Arthur | P. H. Robinson | P. O. Box 1286, Houston, Texas |
| Indianapolis-Laf | 5 | E. G. Thoms | C. E. Chatfield | 711 Illinois Bldg., Indianapolis, Ind. |
| Iowa | 5 | L. F. Wood | B. S. Willis | Iowa State College, Ames, Iowa |
| Ithaca | 1 | W. E. Meserve | B. K. Northrop | Cornell University, Ithaca, N. Y. |
| Kansas City | 7 | G. O. Brown | E. W. Harvey | 2124 Wyandotte Ave., Kansas City, Mo. |
| Lehigh Valley | 2 | J. G. Charest | W. A. Skinner | Pa. Pwr. & Lt. Co., Hazleton, Pa. |
| Los Angeles | 8 | F. E. Dellinger | A. P. Hill | 7046 Hollywood Blvd., Hollywood, Calif. |
| Louisville | 4 | C. M. Ewing | L. O. Adams | General Electric Co., Louisville, Ky. |
| Lynn | 1 | W. K. Dickinson | G. R. Sturtevant | General Electric Co., West Lynn, Mass. |
| Madison | 5 | G. F. Tracy | R. E. Johnson | University of Wisconsin, Madison, Wis. |
| Memphis | 4 | W. A. Gentry | F. L. Christenbury | Memphis Pwr. & Lt. Co., Memphis, Tenn. |
| Mexico | 3 | E. F. Lopez | L. Castro, Jr. | Dept. Elec. y Teleg., Ferrocarilles Nacionales de Mex., Mexico, D. F. |
| Milwaukee | 5 | W. F. Lent | C. D. Brown | 6309 W. McKinley Ave., Wauwatosa, Wis. |
| Minnesota | 5 | H. J. Pierce | R. R. Herrmann | Northern States Pwr. Co., Minneapolis, Minn. |
| Montana | 9 | J. A. Thaler | H. Dale Cline | 312 South 6th Ave., Bozeman, Montana |
| Nebraska | 6 | Clarence Talsma | H. S. Pahren | 724 Union State Bank Bldg., Omaha, Neb. |
| New York | 3 | T. F. Barton | W. R. Smith | United Engrs. & Constructors, 80 Park Pl., Newark, N. J. |
| Niagara Frontier | 1 | F. S. Wahl | J. F. Oehler | 169 Brunswick Blvd., Buffalo, N. Y. |
| North Carolina | 4 | J. B. Lear | R. F. Stainback | Univ. of No. Carolina, Box 1029, Chapel Hill, N. C. |
| Oklahoma City | 7 | E. B. Jennings | C. E. Bathe | Oklahoma Gas & Elec. Co., Oklahoma City, Okla. |
| Philadelphia | 2 | Lewis Fussell | J. L. MacBurney | Elec. Storage Battery Co., Philadelphia, Pa. |
| Pittsburgh | 2 | Thomas Spooner | R. L. Kirk | Duquesne Light Co., Pittsburgh, Pa. |
| Pittsfield | 1 | V. M. Montsinger | S. T. Maunder | General Electric Co., Pittsfield, Mass. |

# Local Sections of the Institute—Continued

| Name | District | Chairman | Secretary | Secretary's Address |
|---|---|---|---|---|
| Portland, Ore. | 9 | F. M. Lewis | V. B. Wilfley | Westinghouse Elec. & Mfg. Co., Portland, Ore. |
| Providence | 1 | I. W. Knight | R. W. Allen | Narragansett Elec. Co., Providence, R. I. |
| Rochester | 1 | C. F. Estwick | L. R. Gillespie | Rochester Tel. Corp., Rochester, N. Y. |
| St. Louis | 7 | F. B. Wipperman | S. L. Hilyard | Illinois Pwr. & Lt. Co., East St. Louis, Ill. |
| San Antonio | 7 | I. A. Uhr | W. L. Eyres | San Antonio Public Serv. Co., San Antonio, Texas |
| San Francisco | 8 | E. F. Maryatt | Roy Wilkins | Pacific Elec. Mfg. Co., San Francisco, Calif. |
| Saskatchewan | 10 | N. W. DuBois | A. B. Coward | Light and Power Dept., Regina, Sask., Canada. |
| Schenectady | 1 | E. E. Johnson | H. H. Race | General Electric Co., Schenectady, N. Y. |
| Seattle | 9 | A. F. Darland | K. L. Howe | Westinghouse Elec. & Mfg. Co., Seattle, Wash. |
| Sharon | 2 | A. P. Bender | E. L. Keene | Westinghouse Elec. & Mfg. Co., Sharon, Pa. |
| Southern Virginia | 4 | Cecil Gray | E. L. Lockwood | Virginia Public Service Co., Newport News, Va. |
| Spokane | 9 | C. F. Norberg | H. B. Tinling | 29 Main Street, Spokane, Wash. |
| Springfield, Mass | 1 | Hans Passburg | J. J. Finn | Roland T. Oakes Co., Holyoke, Mass. |
| Syracuse | 1 | C. W. Henderson | W. E. Mueller | 506 State Tower Bldg., Syracuse, N. Y. |
| Toledo | 2 | I. H. Heitkamp | W. M. Campbell | Toledo Edison Co., Toledo, Ohio |
| Toronto | 10 | I. M. Maclean | J. M. Thomson | 171 John St., Weston, Toronto, Ont., Can. |
| Urbana | 5 | E. A. Reid | L. L. Smith | University of Illinois, Urbana, Ill. |
| Utah | 9 | A. L. Taylor | E. L. Morris | Westinghouse Elec. & Mfg. Co., Salt Lake City, Utah |
| Vancouver | 10 | G. R. Wright | D. M. Johnstone | B. C. Elec. Ry. Co., Ltd., 425 Carrall St., Vancouver, B. C., Can. |
| Washington | 2 | T. J. MacKavanagh | E. T. Walker | Bliss Electrical School, Washington, D. C. |
| Worcester | 1 | H. A. Maxfield | R. P. Bullen | General Electric Co., Worcester, Mass. |
| Total 60 | | | | |

# Student Branches of the Institute

| Name and Location | District | Counselor |
|---|---|---|
| Akron, Univ. of, Akron, Ohio | 2 | Paul C. Smith |
| Alabama Poly. Inst., Auburn, Ala | 4 | |
| Alabama, Univ. of, University, Ala | 4 | F. R. Maxwell, Jr. |
| Arizona, Univ. of, Tucson, Ariz | 8 | J. C. Clark |
| Arkansas, Univ. of, Fayetteville, Ark | 7 | W. B. Stelzner |
| Armour Inst. of Tech., Chicago, Ill | 5 | E. H. Freeman |
| British Col., Univ. of, Vancouver, B. C | 10 | E. G. Cullwick |
| Brooklyn, Poly. Inst. of, Brooklyn, N. Y | 3 | C. C. Whipple |
| Bucknell Univ., Lewisburg, Pa | 2 | G. A. Irland |
| Calif. Inst. of Tech., Pasadena, Calif | 8 | R. W. Sorensen |
| Calif., Univ. of, Berkeley, Calif | 8 | L. E. Reukema |
| Carnegie Inst. of Tech., Pittsburgh, Pa | 2 | George Porter |
| Case Sch. of Ap. Science, Cleveland, Ohio | 2 | H. B. Dates |
| Catholic Univ. of America, Washington, D. C | 2 | T. J. MacKavanagh |
| Cincinnati, Univ. of, Cincinnati, Ohio | 2 | W. C. Osterbrock |
| Clarkson College of Tech., Potsdam, N. Y | 1 | |
| Clemson Agri. Col., Clemson College, S. C | 4 | S. R. Rhodes |
| Colorado State Agri. Col., Ft. Collins, Colo | 6 | H. G. Jordan |
| Colorado, Univ. of, Boulder, Colo | 6 | W. C. DuVall |
| Cooper Union, New York, N. Y | 3 | A. J. B. Fairburn |
| Cornell University, Ithaca, N. Y | 1 | E. M. Strong |
| Denver, Univ. of, Denver, Colo | 6 | R. E. Nyswander |
| Detroit, Univ. of, Detroit, Mich | 5 | H. O. Warner |
| Drexel Inst., Philadelphia, Pa | 2 | E. O. Lange |
| Duke Univ., Durham, N. C | 4 | W. J. Seeley |
| Florida, Univ. of, Gainesville, Fla | 4 | Joseph Weil |
| Georgia School of Tech., Atlanta, Ga | 4 | T. W. Fitzgerald |
| Harvard Univ., Cambridge, Mass | 1 | C. L. Dawes |
| Idaho, Univ. of, Moscow, Idaho | 9 | J. H. Johnson |
| Illinois, Univ. of, Urbana, Ill | 5 | C. E. Skroder |
| Iowa State College, Ames, Iowa | 5 | F. E. Johnson |
| Iowa, State Univ. of, Iowa City, Iowa | 5 | E. B. Kurtz |
| Kansas State Col., Manhattan, Kansas | 7 | R. G. Kloeffler |
| Kansas, Univ. of, Lawrence, Kans | 7 | D. C. Jackson, Jr. |
| Kentucky, Univ. of, Lexington, Ky | 4 | E. A. Bureau |
| Lafayette College, Easton, Pa | 2 | L. J. Conover |
| Lehigh Univ., Bethlehem, Pa. | 2 | N. S. Hibshman |
| Lewis Inst., Chicago, Ill | 5 | F. A. Rogers |
| Louisiana State Univ., Baton Rouge, La | 4 | M. B. Voorhies |
| Louisville, Univ. of, Louisville, Ky | 4 | J. M. Roberts |
| Maine, Univ. of, Orono, Maine | 1 | W. E. Barrows |
| Marquette Univ., Mailwaukee, Wis | 5 | |
| Mass. Inst. of Tech., Cambridge, Mass | 1 | W. H. Timbie |
| Mich. Col. of Mining & Tech., Houghton, Mich | 5 | G. W. Swenson |
| Michigan State Col., East Lansing, Mich | 5 | W. A. Murray |
| Michigan, Univ. of, Ann Arbor, Mich | 5 | S. S. Attwood |
| Milwaukee, Sch. of Engg. of, Milwaukee, Wis | 5 | V. M. Murray |
| Minnesota, Univ. of, Minneapolis, Minn | 5 | J. H. Kuhlmann |
| Mississippi State Col., State College, Miss | 4 | L. L. Patterson |
| Missouri Sch. of Mines & Met., Rolla, Mo | 7 | I. H. Lovett |
| Missouri, Univ. of, Columbia, Mo | 7 | M. P. Weinbach |
| Montana State Col., Bozeman, Mont | 9 | J. A. Thaler |
| Nebraska, Univ. of, Lincoln, Neb | 6 | F. W. Norris |
| Nevada, Univ. of, Reno, Nevada | 8 | S. G. Palmer |
| Newark Col. of Engg., Newark, N. J | 3 | J. C. Peet |
| New Hampshire, Univ. of, Durham, N. H | 1 | L. W. Hitchcock |
| New Mexico, Univ. of, Albuquerque, N. M | 7 | F. M. Denton |
| New York, Col. of the City of, New York, N. Y | 3 | Harry Baum |
| New York Univ., Univ. Heights, N. Y | 3 | H. N. Walker |
| North Carolina State Col., Raleigh, N. C | 4 | R. S. Fouraker |
| North Carolina, Univ. of, Chapel Hill, N. C | 4 | W. J. Miller |
| North Dakota Agri. Col., Fargo, N. D | 6 | H. S. Rush |
| North Dakota, Univ. of, Grand Forks, N. D | 6 | H. F. Rice |
| Northeastern Univ., Boston, 17, Mass | 1 | W. L. Smith |
| Notre Dame, Univ. of, Notre Dame, Ind | 5 | J. A. Caparo |
| Ohio Northern Univ., Ada, Ohio | 2 | I. S. Campbell |
| Ohio State Univ., Columbus, Ohio | 2 | F. C. Caldwell |
| Ohio Univ., Athens, Ohio | 2 | A. A. Atkinson |
| Oklahoma Agri. & Mech. Col., Stillwater, Okla | 7 | Albrecht Naeter |
| Oklahoma, Univ. of, Norman, Okla | 7 | F. G. Tappan |
| Oregon State Col., Corvallis, Ore | 9 | E. C. Starr |
| Pennsylvania State Col., State College, Pa | 2 | L. A. Doggett |
| Pennsylvania, Univ. of, Philadelphia, Pa | 2 | C. D. Fawcett |
| Pittsburgh, Univ. of, Pittsburgh, Pa | 2 | H. E. Dyche |
| Pratt Inst., Brooklyn, N. Y | 3 | C. C. Carr |
| Princeton Univ., Princeton, N. J | 2 | Malcolm MacLaren |
| Purdue Univ., Lafayette, Ind | 5 | A. N. Topping |
| Rensselaer Poly. Inst., Troy, N. Y | 1 | F. M. Sebast |
| Rhode Island State Col., Kingston, R. I | 1 | Wm. Anderson |
| Rice Inst., Houston, Texas | 7 | J. S. Waters |
| Rose Poly. Inst., Terre Haute, Ind | 5 | C. C. Knipmeyer |
| Rutgers Univ., New Brunswick, N. J | 3 | F. H. Pumphrey |
| Santa Clara, Univ. of, Santa Clara, Calif | 8 | E. F. Peterson |
| South Carolina, Univ. of, Columbia, S. C | 4 | T. F. Ball |
| So. Dak. State Sch. of Mines, Rapid City, S. D | 6 | J. O. Kammerman |
| South Dakota, Univ. of, Vermillion, S. D | 6 | C. W. Caldwell |
| So. California, Univ. of, Los Angeles, Calif | 8 | N. C. Clark |
| Southern Methodist Univ., Dallas, Texas | 7 | H. F. Huffman |
| Stanford Univ., Stanford, Calif | 8 | W. B. Kindy |
| Stevens Inst. of Tech., Hoboken, N. J | 3 | H. C. Roters |
| Swarthmore Col., Swarthmore, Pa | 2 | Lewis Fussell |
| Syracuse Univ., Syracuse, N. Y. | 1 | C. W. Henderson |
| Tennessee, Univ. of, Knoxville, Tenn | 4 | J. G. Tarboux |
| Texas Agri. & Mech. Col., Col. Station, Texas | 7 | H. C. Dillingham |
| Texas Tech. Col., Lubbock, Texas | 7 | C. V. Bullen |
| Texas, Univ. of, Austin, Texas | 7 | J. A. Correll |
| Utah, Univ. of, Salt Lake City, Utah | 9 | J. H. Hamilton |
| Vermont, Univ. of, Burlington, Vt | 1 | L. P. Dickinson |
| Virginia Military Inst., Lexington, Va | 4 | S. W. Anderson |
| Virginia Poly. Inst., Blacksburg, Va | 4 | Claudius Lee |
| Virginia, Univ. of, University, Va | 4 | W. S. Rodman |
| Washington, State Col. of, Pullman, Wash | 9 | O. E. Osburn |
| Washington Univ., St. Louis, Mo | 7 | W. L. Upson |
| Washington, Univ. of, Seattle, Wash | 9 | J. R. Shuck |
| West Virginia Univ., Morgantown, W. Va | 2 | A. H. Forman |
| Wisconsin, Univ. of, Madison, Wis | 5 | C. M. Jansky |
| Worcester Poly. Inst., Worcester, Mass | 1 | C. D. Knight |
| Wyoming, Univ. of, Laramie, Wyo | 6 | G. H. Sechrist |
| Yale Univ., New Haven, Conn | 1 | W. B. Hall |
| Total 109 | | |

At the time of going to press for this issue, the list of student officers was not sufficiently complete to include.

# Affiliated Student Society

Brown Engineering Society............Brown Univ., Providence R. I.

# Industrial Notes

**Westinghouse Employes Exceed Sales Quota.**—Final reports of the Westinghouse Employes' sales campaign show a sales total of more than $2,900,000. Every employe was to sell at least one appliance. This average was beaten more than 50 per cent and the volunteers closed over 80 per cent of their prospects.

**Electrotrim Appointments.**—Announcement has been made by Electrotrim, Inc., Union City, Ind., manufacturers of the newly approved and labeled Electrotrim line of two-wire, non-metallic extension wiring, of the appointment of James S. Mahan as sales manager, and L. E. Fuller as special field representative. Both Mr. Mahan and Mr. Fuller were previously associated with Steel and Tubes, Inc.

**New Resistor Company.**—The Atlas Resistor Company, specializing in the manufacture of pack-wound tubular resistors, has been formed with headquarters at 423 Broome St., New York. W. A. Merrill, general manager of the organization, was previously associated with F. A. D. Andrea, Inc., and the Polymet Manufacturing Co. W. John Killoch, formerly of the David Killoch Co., is sales manager.

**Potential Transformers.**—The Allis-Chalmers Mfg. Co., Milwaukee, announces a new line of indoor, oil filled potential transformers, designated type PO, rated 200 va capacity, suitable for accurate metering service or for tripping or relay voltage supply. These are available for 6,900, 11,500 and 13,800 volt service, 60 or 25 cycles and the features of the new line are described as: high safety factor in insulation strength in the primary winding; liberal sized primary porcelain; internal parts cover suspended, facilitating inspection; fixed secondary terminals inclosed in conduit terminal compartment.

**New Power Reduction Unit.**—The Merkle-Korff Gear Co., Chicago, is producing a small, low priced power reduction unit with a wide range of applications due to its compactness and extreme flexibility. The gears run in grease which is sealed in, insuring positive lubrication and quiet operation. The unit can be supplied in any speed from a motor speed of 3,000 rpm down, either for clock-wise or reverse rotation. The unit is so constructed as to be easily attached to any device or mechanism. Induction or synchronous type motors are used.

**Pocket Foot-Candle Meter.**—According to the manufacturer, many simplified and new photocell applications with relays and indicating instruments have been made possible through the new Weston Photronic photoelectric cell. The latest of these applications, by the Weston Electrical Instrument Corporation, Newark, N. J., is a pocket size foot-candle meter built especially for salesman's use, calibrated to read directly on three ranges—50, 250, or 500 foot-candles. One cell is used as an adjustable light collector, with readings appearing on a scale 2.36 inches in length. The cell and instrument are housed in a neat, black, moulded case, measuring approximately $3^{3}/_{8}$ x 7 x $2^{1}/_{4}$ inches.

**Oilproof Portable Cable.**—In certain types of service, portable cords are subjected to the continual attack of oil resulting in deterioration not only of the outer coverings, but eventually of the insulation. To meet this condition the Okonite Company, of Passaic, N. J., has developed a full line of portable cords and cables having a special outer sheath which is impervious to the destructive acting of oil or grease. This line of cords and cables is called "Oilproof Okocord." As the name implies, the new cord possesses all the good qualities of the Okocord line, plus continued resistance to oil, thus rendering it highly suitable for use around machine shops, garages, refineries, oil wells, etc. Strong sunlight and ozone also have little effect on this cord.

**More Capacity for Cables.**—Load-carrying capacity of single-conductor lead-covered cable is increased and operating cost of the circuit is decreased by the use of a new split-type insulator which is so designed that it can be installed on a cable in service, without cutting the conductor. The insulator, a General Electric product, consists of two split alloy wiping sleeves and a split molded-compound insulator. The wiping sleeve halves are soldered together at the assembly, and bolted to the insulator. The joints between the wiping sleeve and the halves of the insulator are made permanently oil-tight and vacuum-tight by compressing oil-proof gaskets between the surfaces. When single-conductor cable is used on alternating-current systems, the current flowing in the conductor induces a voltage in the lead sheath. If the sheath forms a continuous circuit, this induced voltage causes current to flow in the sheath, resulting in sheath losses that produce a heating effect, which decreases the load-carrying capacity of the cable. Insertion of sheath insulators in the lead sheath largely reduces such currents and losses. In addition to the new split sheath insulators there are also ones to be placed in the casing of a joint or in the cable sheath at the end of a joint.

# Trade Literature

**Air Cooled Transformers.**—Bulletin 172, 2 pp., loose leaf. Describes Wagner types AA and AC units in sizes 1 to 50 kva, voltages 100 to 600. Applications are outlined. Wagner Electric Corp., 6400 Plymouth St. St. Louis, Mo.

**Relays.**—Bulletin, 4 pp. Describes "Diamond H" magnetrole relay, applicable in many standard and special applications. It is particularly adapted for motor and light control, time and temperature control, signal equipment, photo-electric cell operation, sign flasher service, etc. Hart Mfg. Co., Hartford, Conn.

**Electrolytic Condensers.**—Catalog 1-C, 16 pp. Describes electrolytic condensers, molded mica condensers. Solar Mfg. Co., 599 Broadway, New York.

**Air Cooled Transformers.**—Bulletin GEA 897B, 16 pp. Describes G-E air cooled transformers, types M and D, for reducing voltage, balancing voltage, boosting voltage, insulating circuits and phase changing. General Electric Co., Schenectady, N. Y.

**Lifting Magnets.**—Bulletin 900, 16 pp. Describes various types of EC & M lifting magnets and illustrates recent improvements made in these products. Photographs of the magnets in use by various industries are also shown. The Electric Controller & Mfg. Co., Cleveland, O.

**Welding Electrodes.**—Bulletin, 16 pp., entitled "Murex Heavy Mineral Coated Electrodes." Numerous applications of inorganic flux coated welding electrodes are described. The welding of mild steel and boiler plate, stainless steel alloys, manganese steel, high carbon steel, stainless iron, and the building up of railway rail ends, special manganese track work, as well as the repair of castings and heavy parts, is covered. Metal & Thermit Corp., 120 Broadway, New York.

**Industrial Rubber Goods.**—Condensed Catalog, 24 pp., entitled "Engineering Data, Industrial Rubber Goods," giving a simplified, comprehensive outline of the principal Goodrich rubber products for industrial purposes. Included are tables of rubber transmission belting showing horsepower capacities, minimum pulley diameters, leather belt equivalents and list prices. A table on conveyor belts makes it easy to figure the required sizes and plies of a conveyor belt without using a formula. Rubber hose of various types for industrial purposes is also described. The B. F. Goodrich Co., Akron, O.

**Horizontal Bearing Mountings.**—Bulletin S, 36 pp. Describes horizontal mountings, Kingsbury thrust bearings and journal bearings, small to medium sizes. These bearing mountings are widely used in high speed centrifugal pumps, horizontal hydroelectric units and similar services. The standard shaft sizes for these mountings vary from 2 in. up to 9 in. and the thrust bearing capacities from under 1,000 lbs to over 50,000 lbs. The bearings are automatically lubricated and may be water-cooled when necessary. They are suitable for speeds up to 3,600 rpm or more, as well as for lower speeds. Dimension lists and capacities of three types of mountings of combined thrust and journal bearings and similar data on mountings for individual journal bearings are included. Kingsbury Machine Works, Inc., 4324 Tackawanna St., Philadelphia, Pa.

# Electrical Engineering

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## This Month—

### Front Cover

Holtwood hydroelectric and steam plant of the Pennsylvania Water and Power Company, at McCall's Ferry, Pa. The Holtwood hydroelectric plant was the first major development on the Susquehanna River, and lies between the Conowingo and Safe Harbor plants. The hydroelectric plant operates under a head of about 53 ft, the total installed capacity of steam and hydroelectric units being 135,000 kw.

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**Officers and Committees** (For complete listing see p. 678–81, September 1932 issue of ELECTRICAL ENGINEERING.)

A.I.E.E. Section and Branch activities continue to "take the Institute to the membership." About 80 per cent of all members now are located within Section territory. Cooperative relations between Sections and neighboring Branches have continued to receive much attention. *p. 738–40*

SUGGESTIONS for the nomination of 1933 A.I.E.E. officers must be received at Institute headquarters not later than November 15, 1932. *p. 736–7*

TO ASSIST engineering readers who are interested in economics and sociology, The Engineering Foundation has prepared a list of books and references covering a variety of subjects and views in these fields. *p. 745–6*

THERE is a need today for variety in technical education; the development of adult or evening instruction in metropolitan areas is said to offer a partial solution for meeting this need. *p. 698–1*

NOISE measurements are extremely helpful in the present day "war on noise"; such measurements are beginning to be used as a basis of acceptable "quietness," and provide the principal means of detecting noise sources. *p. 705–8*

SPECIALLY designed supporting towers were required to carry electric power transmission lines into the city of Milwaukee over railway right-of-way. *p. 708–11*

HARMFUL vibration in electric power transmission lines can be controlled effectively by properly installed Stockbridge dampers of suitable design. Difficulties experienced with early designs of this damper have been overcome by the use of a high strength steel supporting cable. *p. 696–7*

ABOUT 2,500 persons are estimated to suffer from electric shock annually in the United States; approximately half of that number suffer fatal injuries. Experimental work for determining effective remedial measures to reduce this toll are being continued. *p. 693–6*

DOUBLE conductor electric power transmission lines have about 20 per cent less reactance than single conductor lines having the same weight of conducting metal, but cost more. Formulas have been developed for calculating the electrical characteristics of such lines. *p. 701–4*

FROM the standpoint of interruption to customers, protection of electric power distribution systems from disturbances due to lightning is a problem of major importance. Operating experience shows that lightning arresters provide sufficient protection to justify their installation economically. *p. 716–27*

PIONEERING in the use of large capacity automatically adjustable blade turbines of the propeller type, the Safe Harbor hydroelectric development involved an unusual amount of experimental and engineering study. Limited experience with this type of turbine in this country led to the construction of a hydraulic laboratory for testing model turbines complete with scroll case and draft tube. *p. 728–33*

ATTENDANCE at the 1932 Pacific Coast convention concluded at Vancouver, B. C., on September 2, reached a total of 300 persons—a fitting tribute to the unremitting efforts of the committees in charge. The convention was featured by the usual high quality technical sessions, active student participation, interesting inspection trips, and delightful entertainment and sports events. *p. 734–6.* Some of the discussion presented at technical sessions has been summarized. *p. 737–8*

# 115-Kv Submarine Cable for Columbia River Crossing

**Outstanding among cable installations is the recently completed 115-kv oil filled submarine cable which crosses the Columbia River between the states of Washington and Oregon. Three single-conductor hollow-core 750,000-cir-mil cables having armor wires of hard drawn copper instead of steel, are laid directly on the bed of the river 4 ft apart, and cross 2 channels of the river, 3,460 and 1,360 ft in width. These crossings are connected by an overhead transmission line. A 33-ft maximum difference in the water level of the river necessitated the solution of a number of problems at this installation. The many interesting features are described in this article, which is divided into 4 main sections. The first section describes the general reasons for the principal decisions regarding the cable, the second describes the specifications and manufacture, the third describes the design of the field installation, and the fourth covers installation and construction methods. Each section contributes valuable information in its respective field.**

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DELIVERY of electric energy from the new Ariel plant of the Inland Power & Light Company on the Lewis River, Wash., to the load center of the Northwestern Electric Company in Portland, Ore., made necessary the construction of approximately 36 miles of transmission line including a 115-kv submarine cable circuit crossing the Columbia River. The crossing site is just north of Portland city limits and about one mile west of Vancouver, Wash. The river, one of North America's largest streams, forms the boundary between the states of Oregon and Washington.

At the crossing location, shown in Figs. 1 and 2, the river is divided by the $^1/_2$-mile wide Hayden Island into 2 channels, the north channel being 3,460 ft in width and the south channel 1,360 ft. Two separate crossings, one across either channel, were therefore required. These were connected by an *H*-frame wood pole type transmission line as study had shown this to be more economical than to continue the cable underground across the island.

The selection of a nominal voltage of 110 kv for the transmission voltage was determined by an economic analysis of costs at various voltages for delivering energy from Ariel and other possible adjacent developments to load centers in the Portland area; also from consideration of interconnected operation with other utilities in the Northwest. This later consideration has a very important bearing upon the problem since all of the other major companies are now operating or contemplate conversion of principal trunk lines to nominal 110-kv operation. Furthermore, physical interconnections already exist between all of these companies and interconnected operation has been employed for several years past, so the economic advantages to be gained and necessity for planning to meet the increasing demands for interchange capacity have been clearly demonstrated.

For the construction program necessary to meet the load and service requirements, cost comparisons between crossing the river overhead or submarine clearly established the economy of the submarine method. Factors contributing to this were: the requirement of 198 ft minimum clearance above low water; the flat terrain at the crossing site or anywhere in the vicinity; the small increment of cost for a double circuit overhead crossing over a single circuit, making construction for 2 circuits the logical procedure although only one was needed initially; and the unusual requirements of mechanical strength for the overhead construction on account of the occasional very severe ice loading conditions experienced.

Very careful and thorough consideration was given to the idea of trenching of cables in the river bottom in order to provide protection from ship anchors and other forms of external damage. With present river depth at minus 28 ft el (low water at 0) it was decided that the trench would have to be excavated to minus 40 ft el in order to be beneath future ship channel

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Full text of "115-Kv Submarine Crossing of the Columbia River" (No. 32-125) presented at the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., Oct. 10–13, 1932.

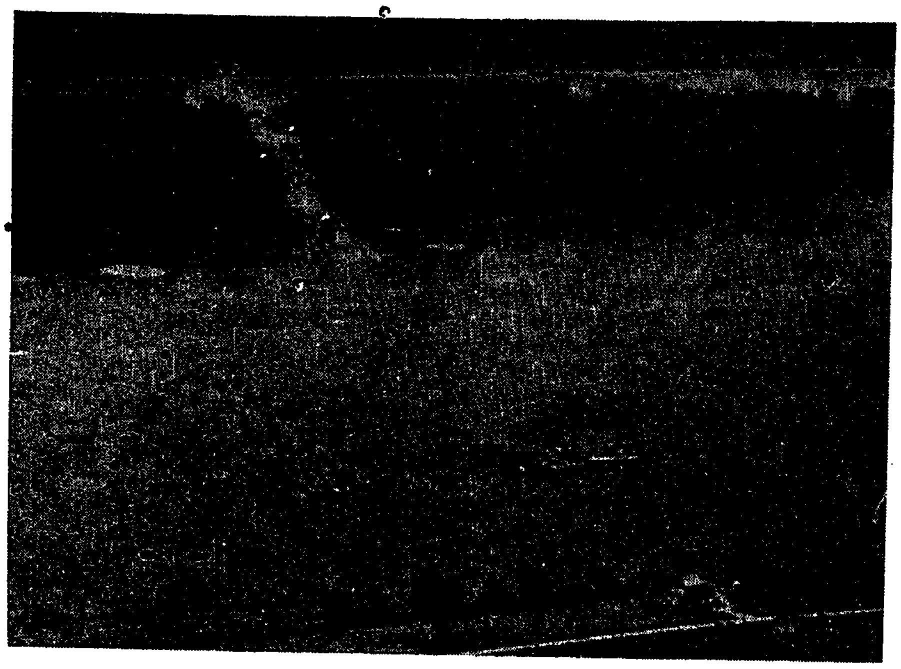

Fig. 1. Site of the 115-kv submarine cable crossing the Columbia River, viewed from the Washington side during construction

bed as well as out of reach of projecting anchor and dredge cutter heads. Such a trench constructed 7 ft wide on the bottom with walls of 1 : 3 slope for withstanding river current would cost from $40,000 to $50,000 and there would be no definite assurance that the trench at right angles to the current could be kept open during laying without additional expenditures for sheet piling or for removing extra sand yardage.

With the cables covered in a trench to minus 40 ft el it is believed that it would not be economically practical to salvage the cable in case defects developed. This fact would therefore necessitate the abandonment of that cable and the writing off of a comparatively large investment. With oil filled cable laid directly on the bed of the river it is believed that the cable can be lifted readily and repaired in case of fault developing. The Northwestern Electric Company has an experience record of 92 submarine cable years, covering 11 3-phase 11,000-volt submarine cables laid directly on the beds of the Columbia and Williamette Rivers in the general vicinity of the new crossing. This experience record, excluding pothead failures, discloses only one failure. In that case failure occurred when the cable was accidentally picked up by a sand digger clam shell. This favorable experience record, combined with greater accessibility and less chance of abandonment, together with fixed charge savings of from $5,200 to $6,500 per yr were responsible for the decision to lay the cable directly on the bed of the river.

During the 3-yr study of this problem considerable time was devoted to consideration of the relative merits of cable with solid type of insulation versus oil filled type. The experience and advice of high voltage cable specialists in several manufacturing and utility organizations throughout the United States was sought. Final decision to specify oil filled cable was based on the following facts:

1. Most favorable operating records of oil filled cable over the past 4 yr, particularly when compared with solid type cable operating at high voltage.
2. High electrical endurance strength of oil filled cable as demonstrated in laboratory and field tests.
3. Ability of oil filled cable to maintain perfect impregnation and prevent void formation and ionization.
4. Development of a satisfactory joint for oil filled type submarine cable.

Three cables were laid directly on the bed of the river 4 ft apart and the shore ends above extreme low water were trenched in and covered with 4 ft of sand. Some slack in the shore ends was provided for use in case of channel changes by the scouring action of the river or by dredging operations.

## Design and Manufacture of the Columbia River Cable

THE hollow core, single conductor, oil filled cable for the 115-kv submarine crossing of the Columbia River has the following specifications and calculated dimensions:

Inside diam of copper supporting spiral, 0.690 in.
Inside diam of conductor strands, 0.790 in.
Outside diam of conductor strands, 1.277 in.
Conductor cross section, 750,000 cir mils.
Thickness of wood pulp paper insulation, 0.560 in. (nominal).
Perforated copper shielding tape (0.005 in.) interlocked with one paper tape.
Inside diam of lead sheath, 2.497 in.
Outside diam of lead sheath, 2.810 in.
Lead sheath $^5/_{32}$ in. 2 per cent tin-lead alloy.
Two layers 16/3 ply tarred jute and asphalt.
Hard drawn copper wire armor (0.238 in. diam).
One layer 16/3 ply tarred jute, asphalt, and whiting.
Overall diam, 3.80 in.
Weight, 20 lb per ft.
Voltage rating, 115 kv, 3 phase, grounded neutral.

Seven reel lengths were manufactured and each length included not only the amount required for installation but also additional cable for test purposes. As manufactured, 3 lengths were approximately 3,780 ft each, 3 more were approximately 1,600 ft and the remaining 832-ft length was shipped on a separate reel to be held in reserve for possible future emergency repair work.

The lead sheath was applied before drying and impregnation treatment. Each length was placed in a steam chamber. Vacuum was applied at each end of the hollow core and drying continued until all moisture was removed. Due to the long lengths involved this drying treatment was necessarily slow, the 3,780 ft lengths requiring 391 hr. After drying impregnation was completed with carefully selected degasified oil having the following characteristics:

Specific gravity, 0.91
Viscosity at 37.8 deg C, 100 (Saybolt)
Pour point, −40 deg C

Following the usual practise, the oil in the core, after impregnation was completed, was continuously maintained under positive pressure by use of one or more cell type pressure reservoir units connected to the cable end. The first principle of oil filled cable practise is to always maintain positive oil pressure at all points of cable length in the factory and during shipment, installation, and operation. The various operations that are closely followed throughout are solely for the purpose of initially removing air, moisture, and other impurities from the entire system, completely filling with oil and maintaining positive oil pressure, so that additional impurities cannot enter through accidental leaks.

After impregnation the cable lengths were subjected to a special volumetric pressure test for assurance that all air and other gases had been removed. The complete lengths or test samples cut from the ends were then subjected to various special and standard acceptance tests, chief among which were the following:

1. Factory reel high potential test, 166,000 volts conductor to sheath for 15 min at 60 cycles, before armoring.

2. Dielectric power factor and ionization factor, 20 to 100 volts per mil, 60 cycles on each reel length before and after armoring. Ionization factor limit 0.2 per cent actual 0 per cent.

3. High voltage time test. Three 75 ft lengths, one before and 2 after armoring. 196,000 volts for 6 hr with 20 per cent voltage steps every 6 hr to failure. The samples failed at 235 kv in 2, 3, and 5 hr.

4. Two 25 ft samples before armoring for 60 cycle dielectric loss test. The average measured power factor was: 0.32 per cent at room temperature, 0.27 per cent at 60 deg C, 0.28 per cent at 70 deg C and 0.30 per cent at 80 deg C.

5. Three 15 ft samples, 2 before and 1 after armoring for bending test. Four cycles of 180° bending at −10 deg C around a mandril 12 times cable diameter. Physical condition noted but electrical tests omitted as meaningless.

After test the 7 shipping lengths were as follows: 3 lengths 3,717 ft each, 3 1,532 ft each, and 1 spare 832 ft length. Each was placed on a separate reel in the body of which was mounted a sufficient number of cell type pressure reservoir units to maintain an oil pressure between 5 lb and 15 lb during shipment and installation. All shipping reel bodies were 7 ft 2 in. wide. The 3 reels for 3,717 ft lengths were 11 ft 2 in. in diameter, and the remaining 4 had a diameter of 9 ft 6 in. Each reel was axially mounted in a permanent cradle with band brakes for unreeling cable. Due to excessive size and shipping weight $45^3/_4$ tons for 3,717 ft units and $21^1/_2$ tons for 1,532 ft units, it was necessary to use special gondola freight cars and load only one reel per car. Obviously, such excessive size and weight required special manufacturing facilities throughout and the various operations presented a very interesting and difficult problem.

## Carrying Capacity of Cable

The carrying capacity of a submarine cable, where the same size conductor is used throughout, is determined by the thermal conditions at the shore ends, the temperature rise of immersed section being, of course, much less. The carrying capacity of this particular installation was more difficult to determine than usual because of the relatively short vertical risers at the ends representing the limiting thermal conditions. Due to transfer of heat from these exposed vertical risers into the earth, the usual formulas for cable in air do not apply exactly and the thermal correction factor was checked by heat run after installation. On the basis of an ambient air temperature of 40.5 deg C, this cable has a conservative rating of 575 amp for maximum conductor temperature of 70 deg C at vertical risers and with copper armor bonded at base of terminals.

If steel armor had been used under the same conditions, the rating would have been only 430 amp, due to excessive armor and sheath losses. The advantages of low resistance copper armor in this respect are fully described in "Losses in Armored Single Conductor Lead Covered A-C Cables," by O. R. Schurig, H. P. Kuehni, and F. H. Buller, A.I.E.E. Transactions, v. 48, 1929, p. 417–34.

## Accessory Design and Manufacture

The following accessories and special installation and maintenance treating equipment were also furnished:

14 single conductor outdoor porcelain terminals or potheads.

6 6 gal and 8 10 gal gravity cell type oil feeding reservoirs.

4 10 gal cell type oil pressure reservoirs for maintaining pressure on emergency oil supply tanks at each terminal.

8 50 gal emergency oil supply tanks with oil level gages, nitrogen gas cylinders, valves, fittings, etc., connected 2 in parallel at each terminal.

800 gal special oil in 50 gal drums for filling terminal equipment after assembly.

4 valve panels (6 valves each) for emergency paralleling or interchange of oil feed for each phase.

2 repair joints with armor box and clamping rings.

Copper tubing, armored lead piping, valves and miscellaneous fittings for connecting oil system.

1 portable, motor driven oil degasifier.

1 portable, motor driven vacuum pump.

1 impregnating bottle.

Rubber vacuum hose, toggle clamps, tanks of specially dried carbon dioxide and miscellaneous fittings.

The outdoor potheads were rated at 132 kv, following the usual practise of using one size larger

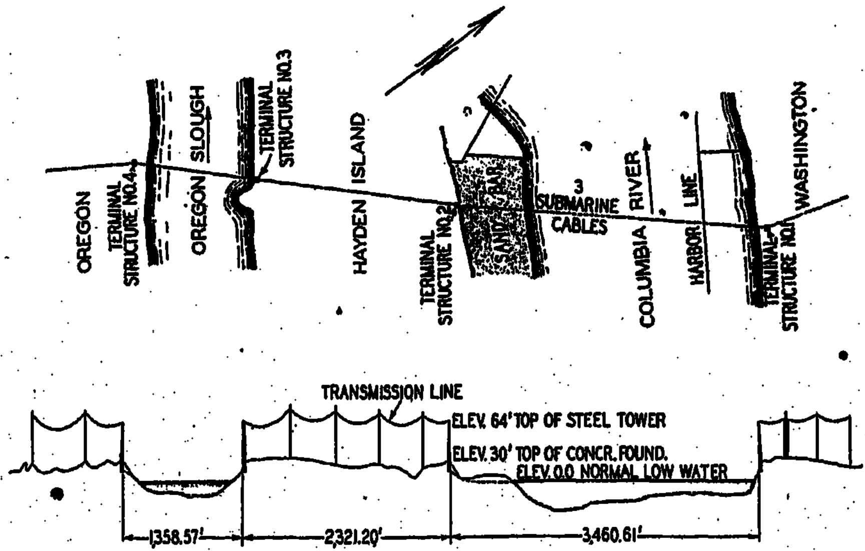

Fig. 2. Plan and profile of the 115-kv submarine cable crossing

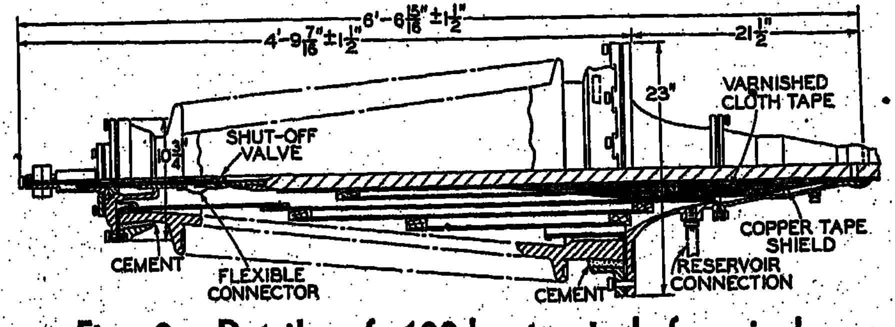

Fig. 3. Details of 132-kv terminal for single conductor oil filled cable

porcelain. A cross sectional drawing of this design is shown in Fig. 3. The guaranteed dry and wet 60 cycle flashover was 375 kv and 280 kv, respectively, and before shipment the potheads were subjected to the following test for leakage: 4 hr vacuum followed by 2 hr oil pressure at 80 deg C. The terminal lugs had a flexible type stud to allow limited movement of the cable conductor during expansion and contraction. There was also a special shut-off valve in the stud so that oil pressure could be maintained in the cable core while the terminal was being vacuum treated and filled with degasified oil after assembly.

All reservoir units, piping fittings, and other accessories were also subjected to rigid tests for leaks before shipment. They were again tested after installation and then carefully dried, evacuated, and filled with degasified oil. The cell type reservoir designs have been described in detail in "Characteristics of Oil Filled Cable," by G. B. Shanklin and F. H. Buller, A.I.E.E. Transactions, v. 50, 1931, p. 1, 411–20; and "Oil Pressure Reservoirs for Underground Cable," by T. C. Aitchison, *General Electric Review*, July 1931, p. 410–15. The first of these also gives a general outline of the principles of oil filled cable practise, and a complete bibliography.

## Design of Field Installation for the Columbia River Cable

THE 4 terminal structures of the 115-kv submarine cable crossing of the Columbia River consist of reinforced concrete bases and platforms supporting cable terminals and accessories, and steel dead end structures for the overhead lines. The details of the terminal structures are shown in Fig. 4.

The decks of these 4 structures are all at the same elevation and are above the usual high water level, but the lower portions will be submerged at high water. The deck of each structure is surrounded by a barrier of steel plate to protect the potheads and accessories from bullets of youthful sportsmen who frequent the neighborhood, and facing the water is a large sign warning against anchorage.

The structure on the Washington side of the main channel has a foundation of wooden piles. This structure is nearer to the water's edge than the others and is adjacent to the ship channel. No piles are used underneath the other structures. Jetties or dykes for protection against undercutting and damage by floating objects during flood periods will be provided for the structures on both sides of the main river channel when deemed necessary.

The steel dead end overhead structures are mounted on the decks of the concrete terminal structures. They are self-supporting and are designed to withstand the maximum expected strain under heavy ice loading of the 795,000 cir mil A.C.S.R. overhead conductors. To guard against failure from unforeseen loading conditions each conductor is dead-ended through a shearpin designed to fail at the value corresponding to the maximum safe strain on the structure.

### ANCHORING

Anchoring of the cables is accomplished by the use of 2 concrete dead-men at each terminal structure. Chains are carried back from these dead-men to the 3 cables. Attachment to the cables is made by means of basket grips, this attachment being considered sufficient due to the fact that a considerable section of cable between the structures and the water's edge is buried in the sandy river bank, which will take up a considerable amount of pulling tension.

### BONDING AND GROUNDING

Due to the fact that the cable armor is hard drawn copper some special problems were encountered in the bonding and grounding of this installation. During operation the armor carries a current almost as great as that in the conductor and for this reason carefully designed and installed high capacity bonds are necessary.

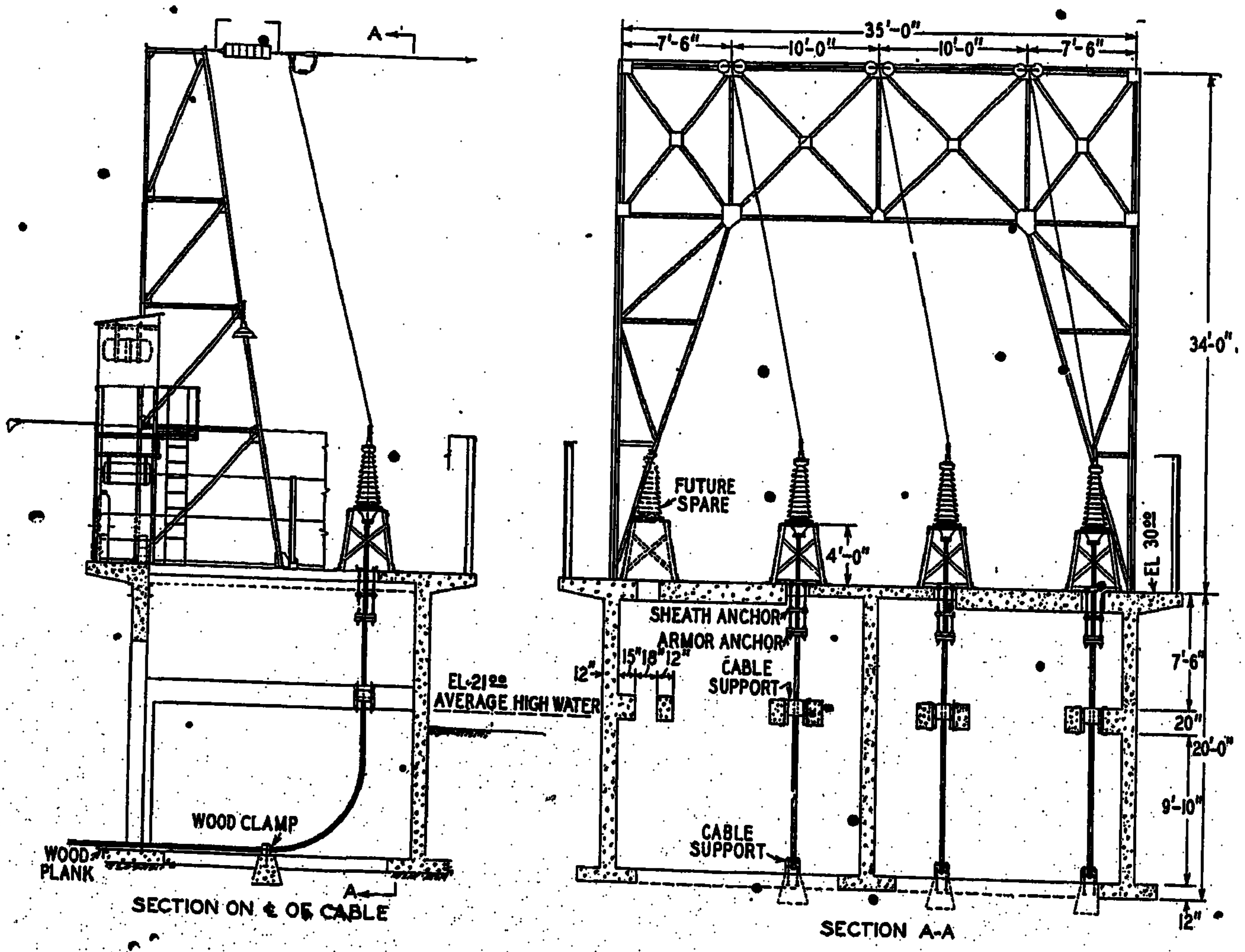

**Fig. 4. Outline of design for terminal structures. Structure No. 1 differs slightly, having a foundation of wooden piles**

Careful study of probable electrolysis conditions, including analysis of the river water, indicated that there should be very little corrosion due to electrolysis. The water has a comparatively high sulphate content. If electrolysis does have a tendency to start at any point, the lead sheath soon becomes coated with a tough, permanent film of lead sulphate, thus automatically stopping the action. However, since with copper armor any corrosion which might occur would affect the anodic lead sheath and not the armor, it was considered advisable to take all possible precautions against damage by corrosion. To this end the armor strands of the 3 cables are bonded together at each end separately from the sheaths, the latter also being bonded together separately and grounded. The 2 sets of bonds are connected together by a removable jumper, both armor and sheath being grounded when this jumper is in place. The idea of this arrangement is to permit periodically inserting an ammeter between the armor and sheath and testing for electrolysis currents. If appreciable currents should develop the sheath and the armor can then be separated by removing the jumper or they can be connected through a battery supplying a potential which is counter to the electrolysis potential.

Arrangement of the grounding system is shown in Fig. 5. The ground electrodes consist of a series of driven rods interconnected with each other and with all equipment and structures, forming a low resistance grounding network.

### Lightning Protection

The lightning protection for the cables and terminals consists of simple spillway gaps mounted across the dead end insulator strings at each terminal structure. They are well grounded to the grounding network which, in turn, provides a short and effective connection to the cable sheaths. The gap setting for operation at 115 kv is 30 in. between points, this being considerably below the impulse insulation strength of the cable and terminals and also somewhat below the maximum recommended setting of 36 in. given by the manufacturer of the cable and accessories. It is also somewhat higher than the maximum expected switching surge voltages, so that lightning should be the only cause for flashover. Flashover of these gaps may involve a trip-out of the transmission circuit in a manner similar to that of a lightning stroke occurring at any other point of the line.

On account of the fog and contamination condition existing along the river, a leakage distance of 80 in., equivalent to 1.2 in. per kv to ground, is provided on the terminal bushings. Two strings in yoke each of 7 suspension units giving leakage distance of approximately 90 in. are used on the dead ends. No pedestal insulators are required with the simple structure design employed.

### Oil Level Alarm System

Since the installation is somewhat remote from the nearest attended substation it was considered advisable to provide remote indication of oil level conditions in the oil reservoirs. Such indication is provided by alarm devices at the oil reservoirs, which devices are connected to telephone lines terminating in Vancouver substation. By a system of resistances individual indication of the different reservoirs can be given over a single telephone line from a given location, the indications being obtained by an ammeter type of indicator in the station. Only 3 of the structures are equipped with this signal system, namely, the 2 on the main channel and the 1 on the north side of Oregon Slough. Fig. 6 is a diagram of this signal system.

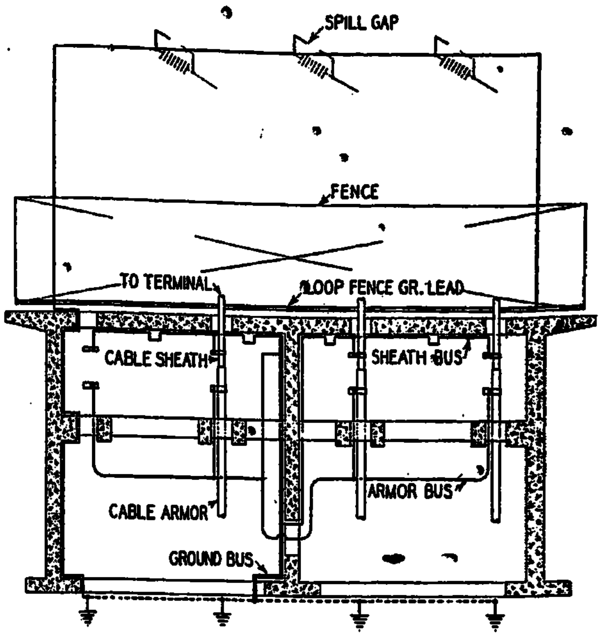

**Fig. 5. Bonding and jointing arrangements at terminal structures**

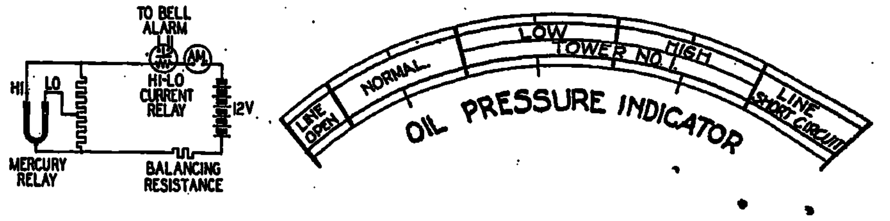

**Fig. 6. (Below) Oil pressure signal system and indicator ammeter scale**

### Emergency Oil Supply

In case of damage to the cable (as for instance by a ship's anchor) which results in an oil leak, considerable time must elapse before the cable can be raised and the damage repaired. It was therefore considered advisable to provide emergency oil storage so that continuous oil flow can be maintained until repairs are effected. This emergency storage consists of simple drum type reservoirs, 2 of 50 gal capacity each for each terminal structure, with suitable piping and valve arrangement to connect these reservoirs with the cable oil system when needed. The valves are hand operated. These reservoirs are provided with tanks of nitrogen under pressure not normally in contact with oil, but with valve arrangements by which the oil in the tanks can be displaced by the nitrogen under emergency conditions. The contact of nitrogen with the oil for short periods of time is not considered especially objectionable, although contact for longer periods of time would be definitely deleterious. The nitrogen is supplied in ordinary high pressure cylinders fitted with special reducing valves. Safety valves are provided to limit the pressure of the oil when forced by the nitrogen gas from the emergency tanks to the cable oil system. The nitrogen is required to be extra dry and the cylinders are required to be dried out before the nitrogen is introduced. Since it is necessary to avoid contact of the oil in the emergency tanks with air at all times during normal operation these tanks are serviced by small auxiliary reservoirs of the expansible cell type which maintain positive oil pressure in the main tanks at all times. This oil piping system is shown in Fig. 7.

### Oil Pressure and Flow Characteristics

During installation great care was taken to maintain positive oil pressure at all times as a safeguard against accidental leakage and also during periods when cable ends were opened for terminal assembly. Under these conditions a predetermined value of oil flow must be maintained, just sufficient to prevent entrance of moisture or air. During operation the same problem exists and, in the case of submarine cable, the surrounding water pressure at different points of the profile must be considered.

Submarine cable in long lengths presents a more difficult oil feed problem than ordinary underground cable. The limiting conditions are, maintenance of positive oil pressure at middle of cable length during coldest winter weather, without exceeding a safe oil pressure on sheath at low water level under full load summer conditions. The armor gives some support to the sheath and the practise is never to exceed a pressure of 20 lb per sq in. at low water level. Water is more dense than oil. There is, approximately, 1 lb gain in head pressure of water for every 30 ft of depth, as compared with oil. The head pressure of oil is approximately $2^1/_2$ ft per lb.

The Columbia River crossing was particularly difficult because of the great difference (33 ft) between low and high water levels. The maximum depth in the middle of the channel at low water level is 30 ft, giving a depth of 66 ft at high water. After a careful study of conditions it was decided to use gravity feed reservoirs mounted at the same level (44 ft above low water) at both ends and feeding toward middle of cable length. This represented an oil pressure of 18 lb per sq in. on the sheath at low water level and left only 1 or 2 lb margin of oil pressure over water pressure at middle of length when load is dropped in the winter at high water level. The margin is sufficient, however, since the assumed conditions are extreme and of only transient nature, the pressure drop in the cable core lasting for less than an hour after load is dropped.

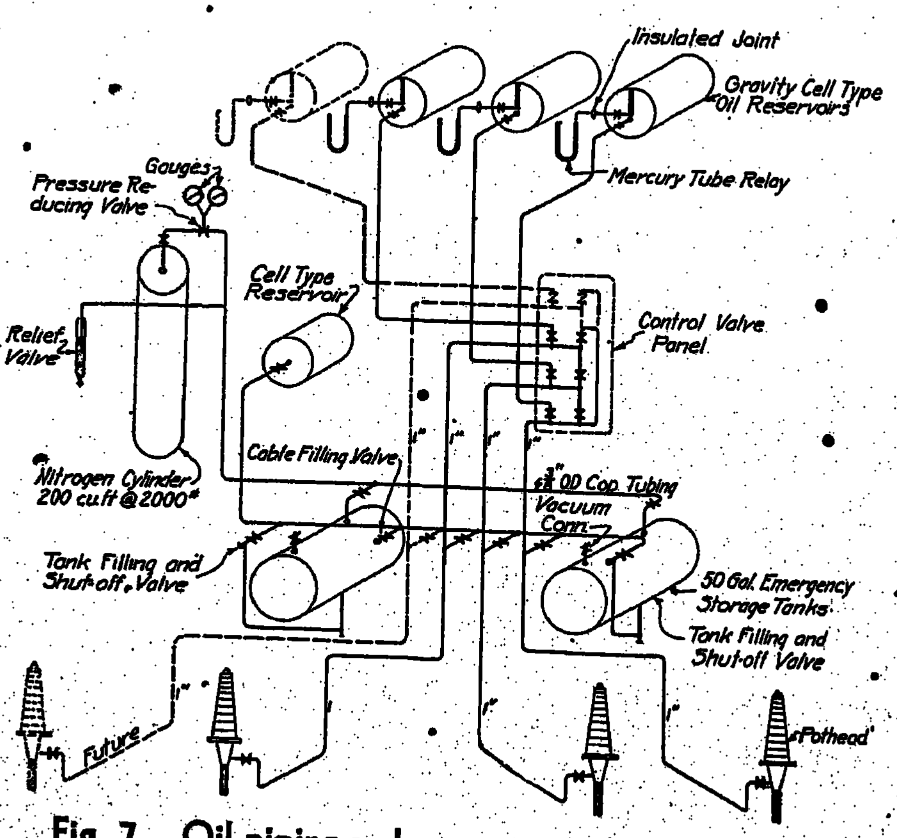

Fig. 7. Oil piping and arrangement for emergency oil supply

These limiting conditions, and the need of utilizing all available oil pressure, did not allow the use of restrictors for limiting oil flow in hot weather in case of accident. In the winter such restriction is not needed but in the summer the reservoirs would empty at a fairly rapid rate in case of a "full open" accidental leak in the system.

This question was given careful study. Space does not allow inclusion of details. Briefly summarized, the conclusions are:

1. The regular switch signal or the oil level alarm relays will give warning immediately or soon after the accident, allowing an emergency crew to be on the scene within 1 or 2 hr.
2. The position of the failure, and other factors, will determine whether the reservoirs involved are exhausted of oil by that time. If not, the emergency oil supply is turned on and the nitrogen gas pressure adjusted (20 lb limit) to maintain an oil flow not greater than 6 gal per hr. This will entirely prevent entrance of water or air in the system and the flow can be maintained until the damage is located and repaired.
3. Even if one or more reservoirs are found exhausted the water will enter the cable core very slowly, if at all, and will have traveled only a short distance by the time the crew arrives. Emergency oil flow will then be adjusted as described, the oil leak located and the cable picked up, not at point of leakage, but 200 ft on each side. It will be cut under oil flow at these points and tested for moisture, repeating the operation in 100 ft steps if necessary. A length of replacement cable will then be spliced in.

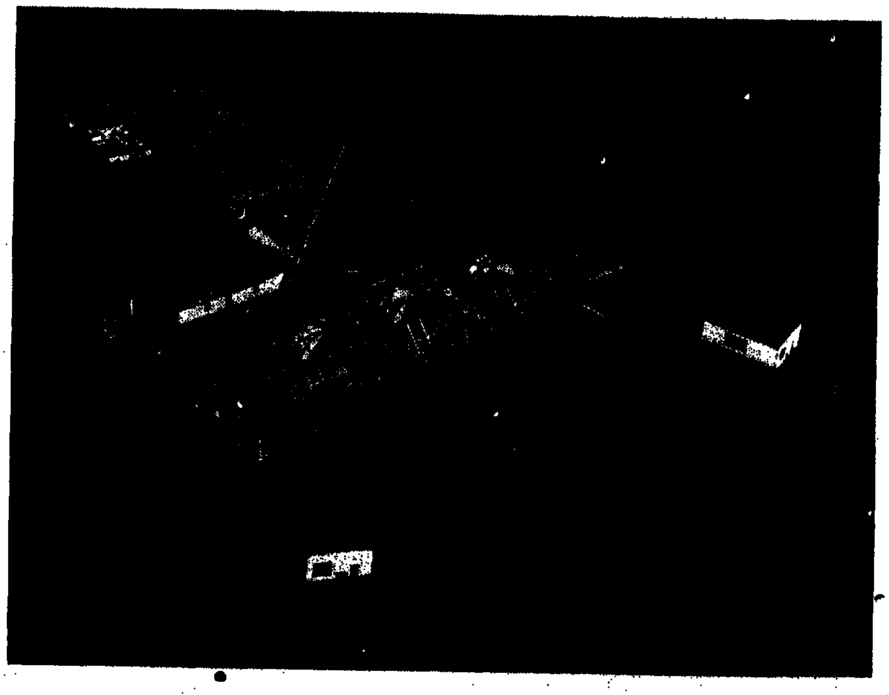

Fig. 8. Floating equipment used while laying cable

The repair joints, held in stock for such emergency use are of standard design successfully used in previous conduit installations with the exception that the spun copper casing is protected by a cylindrical armor box having bolted armor clamps at each end. The cable paper is stepped and the usual low loss varnished cambric tape used for reinforcement wrappings. The halved connector is of the double shut-off plug design that has proved so successful in the past. The copper casing is 3 ft 8 in. long by 6 in. diam. The armor box is 4 ft $2^1/_2$ in. long by 8 in. diam.

## Installation Procedure for the Columbia River Cable

THE importance of the 115-kv submarine cable crossing of the Columbia River, the unusually great size of the reels of cable, and the fact that this was the first submarine installation of oil filled cable to be made in this country, set a task of a new order for the construction forces, and created many unusual construction problems.

Several weeks before the installation was started, a school was set up for the construction personnel and intensive training was carried out. This included such work as making up pothead connections by the use of short lengths of scrap cable. Undoubtedly it was this training together with very careful engineering of the construction work that enabled the installation to be made without serious mishap.

### BARGE EQUIPMENT

Equipment suitable for laying the long heavy lengths of submarine cable was difficult to assemble from a harbor the size of Portland's, and it was only after considerable effort that necessary equipment at a reasonable rental cost was obtained. This equipment as finally assembled consisted of a flat-deck barge, 400 ton capacity, 125 ft long, 32 ft wide, on which the 3 cable reels for each crossing and control equipment were placed. As auxiliary to the cable barge, a steam dipper dredge barge was utilized as a derrick, and in addition there were 2 small gasoline donkey scows from the Port of Portland's dredging equipment, a spare flat-deck barge for use as spare deck space, and 2 small derrick tugs, one for use in changing anchor lines and anchors and one for emergency.

The main barge was arranged for laying the 3 cables at each crossing simultaneously, the reels being mounted in tandem for proper deck load distribution. The 2 reels nearest the laying end, or stern of the barge, were raised sufficiently to allow the cable from the reel forward to pass underneath. Easy running rollers were placed at such points as to eliminate all possible friction. An overhanging timber structure was constructed at the stern of the main barge, with rollers arranged for a minimum safe bending radius of cable as it was fed overboard, and which spaced the cables 4 ft apart. The 2 flanges of each reel were equipped with friction band brakes, one used for laying control and one for emergency.

Calculations for running lines and strains when laying the cable were made on the basis of maintaining the main barge sidewise to river current, which at the time of laying was approximately 7 miles per hr. A donkey scow was placed at bow and stern on the upstream side of the cable barge. Two steel lines, with large anchors attached from each of the donkey scows, were maintained upstream while laying and moved in successive steps across the river. The derrick barge was held alongside the main barge on the downstream side, with steel lines, also with anchors attached, extending from the donkey drums at bow and stern for control of movement across the river. These anchors were also moved as required. The derrick tugs mentioned were used for changing anchors and to clear lines of driftwood, trees, etc., which were quite heavy at this flood stage of the river. The general arrangement of the equipment is shown in Figs. 8 and 9.

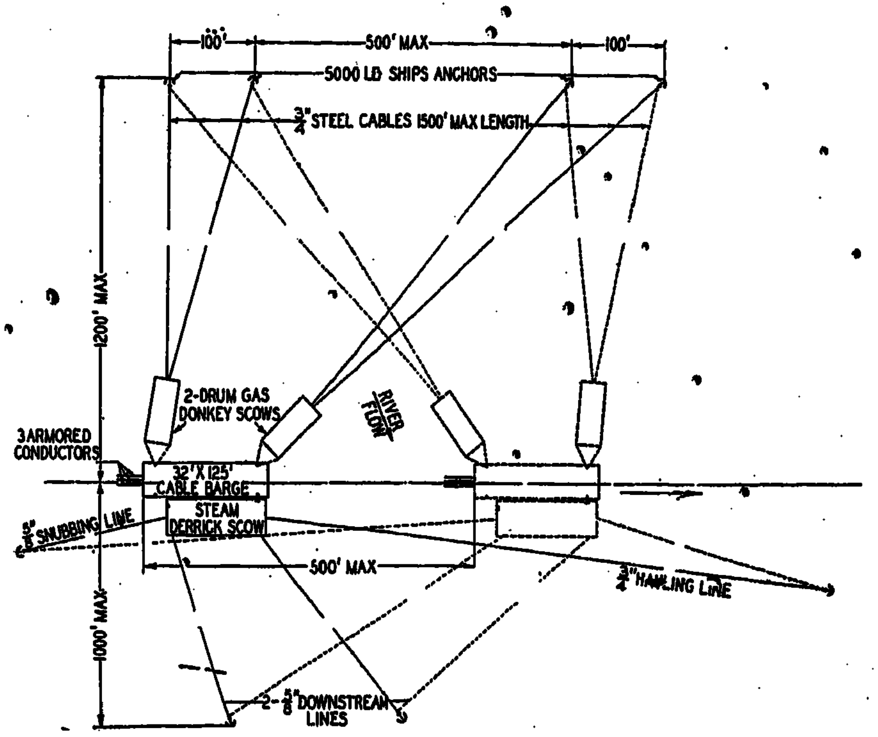

Fig. 9. Arrangement of floating equipment used for laying cable

Buzzer and bell signals were provided to each operation control point. One control was from the point where the cable went overboard, controlling slack and reel movement; another point controlled barge movement across river and the upstream anchor lines from the donkey scows. This control point was in turn controlled by telephone from the shore where men with transits were located for alinement of the cable.

### LAYING THE CABLE

The shorter sections of cable across the Oregon Slough (see Figs. 1 and 2) were laid first, and on a rapidly rising river. The 3 shore ends, one at a time, were pulled over rollers located at frequent intervals, into terminal structure No. 4, by means of lines from derrick hoisting drums fastened to the armor pulling eyes at the cable ends. (The terminal structures are numbered consecutively from 1 to 4, beginning with the one farthest north, as indicated in Fig. 2.) Cables were then clamped in final position with necessary slack above terminal pedestals for terminal installation.

Temporary oil connections were made between the 3 cable ends and the 3 permanent oil pipings which had been installed with permanent oil reservoirs, emergency oil tanks, etc., previous to cable laying operations. Oil supply to the cable was then made from the permanent oil supply apparatus, oil supply to the cable from the temporary pressure reservoirs shipped with the reels being closed off. Reserve supply of oil and the degasifying equipment were connected and made ready to provide against any possible emergency that might arise. After all connections were complete, short slacks were laid just outside terminal No. 4 and temporarily anchored, and the laying of the Oregon Slough crossing started. This laying to a point approximately 300 ft from terminal No. 3, where slack was to be dropped, took 5 hr. Slack, as engineered for this location, was laid out on the deck of the spare barge and lashed in place to cross timbers which were later raised with the derrick and the spare scow pulled from under the suspended cables. The suspended cables were then carefully lowered to the bottom of the river, later checked by a diver as to lay, and then the lashing cut allowing timbers to float to the surface of the river. The laying equipment was then moved to terminal No. 3, the shore end footage of the cable pulled from the reels and placed in the shape of a figure 8 on the deck of the spare barge. Reels were then removed from the main barge deck, ends of the 3 cables were pulled into terminal No. 3 and clamped into proper place. The 3 cables were then one at a time moved over toward the edge of the barge and carefully lowered overboard in final location alongside.

Laying of the 3 longer sections across the main channel was more difficult on account of the extreme high water and heavy current, but was accomplished in the same manner as the Oregon Slough crossing. Laying of these lengths was started from structure No. 1 on the Washington side of the river and laid to terminal No. 2. The crossing time of the river proper was approximately 14 hr, the following 2 days being used in disposing of slack at the outer edge of the 800 ft sand bar and working the barge equipment through the dredged channel to structure No. 2.

The same preparations were made at No. 1, where cable ends were first temporarily connected to the permanent oil reservoir system for any oil emergency condition, as were made at No. 4. These preparations were called into use shortly after the laying process started.

When about 1,000 ft from structure No. 1, the oil pipe connections between the inner end of the cable and the oil reservoirs contained within the reel body was sheared off on account of creepage movement of the inner layers of cable. The man handling the emergency oil apparatus at structure No. 1 immediately noticed a drop in oil pressure and, as instructed, supplied the emergency oil, maintaining the established pressure. Before the crossing of the main channel was completed the oil connections on the 2 remaining cables were also sheared off, also owing to the slippage of the inner layers of cable on the reel drum. The leaks thus developed could not be closed until sufficient cable was taken from the reels to allow access to the inner layer, and at one time it was problematical as to whether there was a sufficient supply of degasified oil available to maintain oil pressure on the cable until oil leakage from broken connections was stopped.

### Terminal Installation

After the cable laying was completed, terminal pothead installation was immediately started at terminal No. 3, the necessary oil flow from cut cable ends being supplied from the permanent oil system through the temporary oil piping at terminal structure No. 4. No difficulty was experienced at any time during installation. The entire structure was temporarily covered with canvas to protect the working deck from rain and, in turn, each terminal location was inclosed with a special tent during taping and terminal assembling operations.

Terminals were next installed at terminal structure No. 4 with oil control for operations at this point through the cable from the permanent oil system at No. 3. The same procedure in rotation was followed for the terminal installation at structures Nos. 2 and 1. In all terminal assembly operations, as well as at other times, telephone communication was maintained between all 4 structures. This communication between structures allowed very close regulation of required oil flow and pressure during terminal installation and also for the final adjustment and testing of the entire oil system.

Aside from the broken oil connection, no difficulty of any serious nature was experienced during the entire installation of cable and terminals.

### Tests and Operation

As soon as the installation was completed a 3-phase 60-cycle short-circuit current heat run was made, temperatures, induced sheath and armor currents, oil volume changes, etc., being carefully measured. This heat run served a 2-fold purpose: it caused

**Table I—Comparison of Calculated and Heat Run Data**

| Circulating Current* (Avg) | | 840 Amp Load | 795 Amp Load |
|---|---|---|---|
| Sheath | Measured | 12.1% | |
| | Calculated | 11.3% | |
| Armor | Measured | 90.3% | |
| | Calculated | 93.2% | |

| Armor Temperatures (Max.) | | 840 Amp Load | 795 Amp Load |
|---|---|---|---|
| Columbia River | | | |
| In air | Measured | 28.0 deg C | |
| | Calculated | 30.1 deg C | |
| Under water | Measured | | 24.1 deg C |
| Oregon Slough | | | |
| In air | Measured | | 30.5 deg C |
| | Calculated | | 29.7 deg C |
| Under water | Measured | 25.4 deg C | |

| Oil Level in Reservoirs | | At 795 Amp Load | At No Load |
|---|---|---|---|
| Columbia River | Measured | 8.0 gal | 4.5 gal |
| | Calculated | 7.88 gal | 4.2 gal |
| Oregon Slough | Measured | 4.8 gal | 2.8 gal |
| | Calculated | 4.53 gal | 3.1 gal |

| Ambient Temperatures | Columbia River | Oregon Slough |
|---|---|---|
| Water Ambient | 15.0 deg C | 16.0 deg C |
| Air Ambient | 17.0 deg C | 18.0 deg C |

* Percentages given are in per cent of ampere load.

uniform dispersion and absorption of any small amounts of impurities that might not have been excluded, and it furnished a final check on all theoretical calculations. Table I gives a summary of these calculations and the essential heat run data.

Operation of the cable under normal conditions since June 19, 1932, to date has been very satisfactory. Cable temperatures and oil level fluctuations have followed the calculated values very closely with varying load conditions.

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# Further Research in Injuries From Electric Shock

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**With approximately 2,500 persons suffering from electric shock annually in the United States, fatally in about 50 per cent of the cases, the problem presented is one of increasing importance. In recognition of this fact, intensive experimental work has been under way at The Johns Hopkins University for some time, supported by funds made available through the generosity of the Committee on Physiology of the Conference on Electric Shock. The accompanying article discusses the effects of injuries produced by surge discharges, and summarizes some of the more important conclusions previously published in ELECTRICAL ENGINEERING.**

ACCIDENTS caused by electric shock in general and by contacts with low voltage circuits in particular are increasing in number with the increasing industrial and domestic use of electrical equipment. Case analyses have shown that individuals between 15 and 30 years of age are most likely to be the victims, perhaps owing to the greater carelessness of youth; and that more men are injured than women. Also, accidents have been found to be more common during the summer months as a result of reduced protection by clothing, and the presence of perspiration which decreases the skin resistance. To supplement the analytical study of the case history of several hundred unfortunate human victims of electrical accidents, laboratory experimental work has been carried on for some time by The Johns Hopkins University in an effort to learn enough about the physiology involved to enable the determination of effective remedial measures that will save human life.

In this laboratory work the injuries produced by electric currents have been studied through analyses of the effects of shocks upon living animals completely anesthetized. Animals differ widely in their ability to withstand electric shocks; dogs are killed by a relatively small current, while rats are much more resistant. The difference lies to a great extent in the behavior of the heart; the adult dog's heart readily is thrown into ventricular fibrillation by a small electric current, and does not recover from that condition spontaneously, whereas the ventricles of a rat's heart apparently do not fibrillate. By ventricular fibrillation is meant the failure of the ventricles of the heart to beat with a coordinated rhythm, the individual muscle fibers contract asynchronously instead.

While these wide variations in reaction make difficult the direct application to man of the results obtained experimentally from animals, the variabilities noted prove to be an aid rather than a hindrance to the progress of experimental work provided the proper animal is selected and the different reactions are kept well in mind. Thus, the authors have used the rat in their studies of the changes in the nervous system, and the dog in their studies of ventricular fibrillation; all animals of course thoroughly anesthetized throughout the entire experimental procedure. The essential features of this experimental work have been covered in previous issues of ELECTRICAL ENGINEERING:

1. "What Are Effects of Electric Shock?" June 1931, p. 406–10.
2. "Nerve Injuries From Electric Shock," December 1931, p. 929–32.
3. "Heart Injury From Electric Shock," April 1931, p. 242–4.

The present article includes results from some new work with an impulse generator, and summarizes a further analysis of previous work.

## INJURIES FROM SURGE DISCHARGES

As the surge or impulse generator is used more and more widely in industry, there has arisen the question

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Written especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

of the danger to life of shocks received from it. In an attempt to obtain some indication of the correct answer to this question, several experiments have been conducted with a small impulse generator, the only resistance in the circuit being the body of the animal under test. Cathode oscillograms showed that under these conditions the current reached a value slightly in excess of 100 amp at 200,000 volts maximum. The steepness of the wave front is shown by the fact that the current reached its maximum value in $^1/_4$ microsecond, with the entire discharge completed in about $4^1/_4$ microseconds. With this apparatus several rats were tested with the results shown in Table I.

With group 1, a clip attached to the desired part of the body and extending several inches above the animal attracted the spark to a particular location. All of the 7 rats tested breathed spontaneously and were active immediately following the shock. The only evidence of abnormality was in the 2 that had received the discharge at the level of the shoulders; their sense of equilibrium was disturbed, and they rolled around in small circles for some 10 minutes, after which they were quite normal. It is evident that under these conditions little or no damage was produced by the surge discharge.

In the second group where 5 rats were suspended so that the surge traversed the entire length of the body, all died despite the use of artificial respiration. In only one of these rats was heartbeat noted following the shock; this rat made a few attempts to breathe, but died ultimately in spite of long continued efforts with artificial respiration. In this group of animals, rhythmic tremors of the striated musculature were observed most markedly in the hind legs.

Table I—Results of Surge Shocks on Rats

| Group | Path of Surge | No. | Recovery | Breathing | Heart Beat | Resuscitation |
|---|---|---|---|---|---|---|
| 1 | Surge entered at: | | | | | |
| | Head | 3 | 3 | Normal | Normal | None needed |
| | Shoulders | 3 | 3 | Normal | Normal | None needed |
| | Rump | 1 | 1 | Normal | Normal | None needed |
| 2 | Tail to head | 4 | 0 | None | None detected | Failed |
| | Back of head to tail | 1 | 0 | Feeble | Feeble | Failed |
| 3 | Back of neck to tail | 4 | 0 | Feeble in 1; none in others | Feeble | Failed |
| 4 | Shoulders to tail | 4 | 3 | 1 normal; others feeble | Normal | Not needed on 1; successful on 2 |
| 5 | Middle of back to tail | 4 | 3 | Normal | Normal | Failed on the 1 requiring it |
| | Right fore leg to tail | 3 | 2 | 1 normal; others feeble | | Not needed on 1; 1 successful; 1 failure |
| | Left fore leg to tail | 4 | 1 | 1 normal; others feeble to none | | Not needed on 1; others failure |
| 6 | Back of neck to abdomen | 4 | 1 | Feeble to none | Feeble | Successful on 1 |

In Group 1 experiments the rats lay on the ground plate. All other experiments were made with the rats suspended

The brain itself was not included in the path of the discharge applied to group 3, but the brain stem and the areas controlling the heart and respiration lay close to the electrode. In all 4 cases the injury to the heart proved fatal in spite of artificial respiration, and in spite of the fact that the heart damage was not so great as that noted where the discharge traversed the entire length of the body.

The 4 animals of group 4 were tested with the surge entering at the level of the shoulder and passing from the tail to the ground plate. Under these conditions, the portion of the brain that controls the heart and lungs did not lie in the direct path of the discharge. One animal breathed at once following the injury and recovered quickly. Another started to breathe spontaneously, but stopped and was saved by artificial respiration. The third also was resuscitated successfully, but the fourth died in spite of initial attempts to breathe. In all these animals their hearts beat strongly following the surge discharge. Marked tremors also were noted, and in one animal the hind legs were weak for an hour after the shock, subsequently becoming quite normal.

Following a surge discharge passing through the 4 animals of group 5 from the mid-thoracic region to the tail, all breathed spontaneously and the heart of each beat strongly following the shock. In one case, however, the breathing subsequently ceased and the animal could not be resuscitated. Also, several animals were tested by being suspended from one fore leg, the spark passing from the tail to the ground plate with the results as noted in the table.

In the tests on group 6 the discharge entered at the back of the neck and left in the mid-abdominal region. On the 4 animals tested in this manner, artificial respiration was used in every case, but with only one recovery. In all animals the heartbeat was weak following the discharge, but improved considerably during the next few minutes. Clonic movements followed the passage of the discharge.

As evidenced by earlier experimental work the heart of a rat is usually but little influenced by electric shock. This, however, is not true in the case of lightning discharge, under which condition the action of the rat's heart was in many cases definitely affected. Immediately following the discharge, either no heartbeat could be detected, or the heart was very feeble, but there was no evidence of ventricular fibrillation. Although in almost every case the discharge of the lightning generator used in these tests produced tremors in the musculature, there was but little evidence of the severe muscular contractions noticed in the earlier experiments with d-c and a-c circuits; in these impulse experiments the chests of the animals were expanded following the discharge.

These experiments with the surge generator again clearly emphasize the importance of the current path through the animal, and check the results already reported for the various current pathways. It is evident also that the amount of nerve tissue lying in the current path bears a direct relationship to the damage to the organism. In the tests, as the brain and nerve centers were eliminated from the current path, the chances of recovery became greater.

## SUMMARY OF EFFECTS PRODUCED BY ELECTRIC SHOCK

Some of the factors of greater importance in cases of electric shock will be summarized in the following paragraphs.

The effects of voltage as indicated by the experiment with rats showed clearly that low voltage a-c shocks are more deadly than d-c shocks of corresponding voltage; that d-c shocks on a 1,000-volt circuit were more deadly than a-c shocks of corresponding voltage; that in either case the injury increases with the increase in voltage.

### Table II—Effects of Voltage

| Voltage | Number Tested | Duration of Shock Sec | Current Milliamp | Per Cent Receiving Artificial Respiration | Per Cent Paralyzed | Per Cent Died | Per Cent Immediate Recovery | Average Resistance Ohms |
|---|---|---|---|---|---|---|---|---|
| A-C—110 | 11 | 10–30 | 25–48 | 90 | 9 | 27 | 64 | 3,091 |
| D-C—110 | 33 | 5–60 | 28–47 | 30 | 3 | 12 | 85 | 2,685 |
| A-C—220 | 28 | 5–14 | 80–200 | 93 | 38 | 34 | 28 | 1,890 |
| D-C—220 | 19 | 5–30 | 100–200 | 74 | 5 | 42 | 53 | 1,635 |
| A-C—500 | 26 | 1–4 | 240–490 | 73 | 50 | 12 | 38 | 1,425 |
| D-C—500 | 37 | 1–4 | 280–640 | 89 | 5 | 46 | 49 | 1,385 |
| A-C—1,000 | 28 | 1–4 | 650–1,200 | 85 | 39 | 32 | 29 | 1,140 |
| D-C—1,000 | 31 | $^{1}/_{10}$–1 | 600–1,100 | 97 | 13 | 58 | 29 | 1,365 |

The danger of contact with high voltage circuits is recognized widely, but the serious and far more prevalent hazard from contacts with low voltage a-c circuits in residences and factories as yet is not sufficiently widely understood for public safety. The danger of contact with low voltage circuits increases as the contact resistances of the body are lowered. When a person who is well grounded comes into contact with a low voltage circuit through a defective electrical device or otherwise, the value of the current may be sufficient to cause death. The majority of such accidents occur in bathrooms, damp cellars, around water and gas piping, and other places where local conditions reduce to a negligible value the contact resistance of the body.

When contact is made with a high voltage circuit, the contraction of the muscles is so violent that often the victim is thrown clear, whereas it is difficult if not impossible for the victim to release his hold in cases of low voltage shock because the muscular contraction is steady rather than violent. When the body forms part of an electric circuit it offers 2 resistances to the passage of current: the contact resistance, and the ohmic resistance of the body proper, that in the case of human beings amounts to approximately 200 ohms. The contact resistance offered by the calloused palm of a laborer may be 100,000 ohms per sq cm, whereas with moisture present that same resistance may fall to 1,200 ohms or less per sq cm. Analyses of experimental data show that the contact resistance drop is of the form of a voltage drop which is practically independent of the current flowing.

In human beings electric currents of from 8 to 10ma are quite painful; at 20ma the muscular contraction is so great that the victim cannot release his hold on the circuit; a current of from 90 to 100ma is considered dangerous.

In human accidents only the voltage of the circuit usually can be determined, leaving in doubt the value of current flow through the body. Sensitivity to electric current varies widely in different individuals and various animals; in general the threshold of sensitivity ranges between 0.5 and 2ma. Experiments reported upon by other qualified investigators have demonstrated that in dogs a current of from 70 to 80ma flowing through the body produces ventricular fibrillation of the heart; that larger currents may cause sufficient muscular contraction to inhibit all heart action. In these latter cases the heart usually resumes rhythmic beat when the circuit is opened.

Not only is total current through the body of importance, but the current density also must be considered. In their laboratory experiments, the authors found that a small animal could not recover from a given shock so readily as could a much larger animal. Perhaps this is one of the reasons for the belief that thin people are more susceptible to electric shocks than are large individuals.

The duration of the contact with electric circuits is of extreme importance in determining whether or not the victim will survive. In general, the hope of successful resuscitation dwindles as the time of contact and the voltage of the shock is increased.

Usually in cases of human accidents but few data are available to reveal the length of time the current flowed through the body of the victim. Fortunately, because of the violent muscular contraction when contact is made with high voltage circuits, the shock is usually of short duration. In cases of low voltage shock, however, the person may be held in contact with a circuit for an appreciable time. Laboratory experiments with animals have borne out the vital importance of the time factor.

Human beings sometimes retain full consciousness while in contact with an electric circuit and are able to call for help, whereas others are rendered unconscious at once.

If the victim recovers, consciousness may return after a few seconds or minutes, and usually the victim is able to return immediately to his work provided the injuries inflicted by the current are not severe. In some instances, however, the unconscious state passes into a deep coma which in turn is interrupted by violent convulsions terminating in death. There are on record several accidents in which unconsciousness followed a shock between 2 fingers of the same hand, or 2 points on the same leg. In such accidents no current flowed through the central nervous system, and the resulting unconsciousness must have been due to the sudden shock and the resulting vasomotor reactions.

That shocks may cause a "block" in the nervous system that will inhibit respiration has been demonstrated conclusively. If artificial respiration is applied promptly and continued for a sufficient time the respiratory nerve center may have opportunity for successful recovery.

Extensive laboratory experiments substantiate the value of prompt and long sustained artificial respiration. In the microscopic examination of the nerve tissues of test animals the injury to the nerve structure was demonstrated clearly. In those animals which could not be induced to breathe following the shock the cell damage was most marked; in some instances the severity of the nerve cell injury was incompatible with life.

Hemorrhages have been found in the spinal cords of many of the rats subjected to laboratory shocks, but injuries of this type are not found in the case of human accidents.

In several animals, however, hemorrhages were found both in the substance of the medulla oblongata and filling the fourth ventricle of the brain; similar hemorrhages are common in legal human electrocutions. Apparent hemorrhages in the lungs have been noted in the case of some human accidents, a condition noted also in the laboratory experiments. Excepting only those which distended the fourth ventricle pressing on the respiratory center and those occurring in the spinal cord, the hemorrhages found in the brains of the rats seldom were responsible for the death of the animals involved.

Convulsions are recorded occasionally as following an electric shock in human accidents, a phenomenon observed also in several of the experimental animals.

The animals so affected were found to be hypersensitive to all sensory stimuli after the shock. In a few cases there was evidence of disturbance to the vestibular mechanism, as shown by the animals walking or running in circles.

The human heart seldom recovers spontaneously from the state of ventricular fibrillation. Some observers of electrical accidents believe that the majority of deaths are caused by this abnormality. Therefore the action of electric current upon the heart is of the greatest importance.

As yet, no specific method has been developed for the recovery of the fibrillating heart in human beings. Nevertheless, in accredited experimental work carried on by other investigators, it has been demonstrated that the fibrillation in a dog's heart can be stopped by the injection of a potassium chloride solution into the carotid arteries. The injection of this solution inhibits all contraction of the heart musculature. The solution is then washed out with physiological saline solution and the heart resumes its normal rhythm.

Permanent disability following electric shock is shown by only a very small percentage of the individuals who have recovered from an electric injury.

Extensive burns following actual contact may be slow in healing, and nerve ends sometimes get caught in the scar tissues thus producing a lasting irritation. In a few instances cataracts of the eyes have been found, and in others, instability of the nervous system for an appreciable time following the shock has been noted. How much of this is caused by actual damage to the nerve cells, and how much should be classed as neurosis, is difficult to say. According to reports published in Germany in 1931, there seems to be the possibility that muscular atrophy may follow electrical accidents either soon or after several months' delay. It is reported that this effect usually is preceded by pain and abnormal sensations in the extremity, and accompanied by vascular disturbances. These data are interesting, but they must be examined critically. In the literature of England and the United States no similar cases of atrophies following electric shock have been found. It is of particular importance, therefore, that these late effects be watched for carefully in the future.

## CAUSES OF DEATH

It is recognized that the heart and the respiratory center in the brain are particularly susceptible to injury by electric currents. From the authors' experimental work with animals and from their analyses of reports of human accidents it is evident that death as an ultimate result of electric shock may occur from several different direct causes:

By asphyxiation caused by the prolonged muscular contraction.

By ventricular fibrillation of the heart, usually believed to be inducted by low voltage shocks.

By destruction of nerve cells in the respiratory center of the brain.

By excessive increase in body temperature as a result of the Joule effect of the shock current.

By severe burns or other resulting complications.

Competent authorities stress the fact that in electrical accidents death often is *only apparent.* Artificial respiration should be begun *immediately* following an accident and continued until the patient recovers or until the cessation of life as an actuality is evident by the onset of *rigor mortis.* Accredited reports list many successful resuscitations following the application of the Schaefer prone pressure method of artificial respiration, in one case success following an 8-hr. effort.

# Conductor Vibration on Transmission Lines—III

**Field tests made in California on a double circuit tower line comprising one aluminum and one copper circuit show that these different types of conductors vibrate under approximately the same conditions and at about the same frequencies, aluminum vibrating with the greater amplitude.**

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Pac. Gas & Elec. Co.,
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A CAREFUL STUDY of the vibration problem on the lines of the Pacific Gas and Electric Company (Calif.) was undertaken after trouble had developed in some of the early damper designs of the Stockbridge type. This trouble was due to fatigue of the supporting messenger strand. Life tests made on these early assemblies soon revealed the necessity of substituting high strength steel strand in place of the ordinary guy strand or Siemens-Martin grade. This substitution changed the characteristics of the damper slightly, but later tests proved that the dampers still were effective. The life tests were made on the damper assemblies using a vibration machine similar to that shown in the Monroe-Templin paper (Fig. 7, p. 487, ELEC. ENGG., July 1932). The revised damper design using the high strength steel was given a life test of more than 100,000,000 cycles without failure. The failures in the supporting strand occurred not at the center clamp or point of maximum stress, but where the cable enters the weight; a point where the strand is subjected to a reversal of stress.

Mr. Monroe and Mr. Templin seem to favor 2 dampers per wire per span wherever possible. I prefer using 4 dampers for any line conductor of 1-in. diam or larger. These 4 dampers should have their spacing so staggered that not more than one damper would be located at a node point for any of the frequencies most often experienced. This method as a rule permits 3 dampers to be so located that they may be fairly effective as dampers. A damper has its greatest efficiency when located at the center of a loop, and the Stockbridge damper is most efficient when the natural period of the damper is approximately that of the vibrating cable. To make a more careful study of damper spacing a test span was

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Full text of a discussion submitted concerning the Monroe and Templin paper "Vibration of Overhead Transmission Lines" published in the July and August issues of ELECTRICAL ENGINEERING and previously presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932. *Not published in pamphlet form.*

erected and this span was vibrated mechanically at from 4 to 22 cycles per second. After studying the damper spacing on this short span the test equipment was transferred to the field, and spans actually in service on line towers were vibrated to obtain data against which the laboratory results might be checked. These tests all seemed to indicate that the use of 4 dampers with staggered spacing was much more satisfactory than the use of only 2 dampers. With modern dampers of the Stockbridge type properly designed and located, I believe vibration can be controlled so effectively that no damage will be done to the conductor.

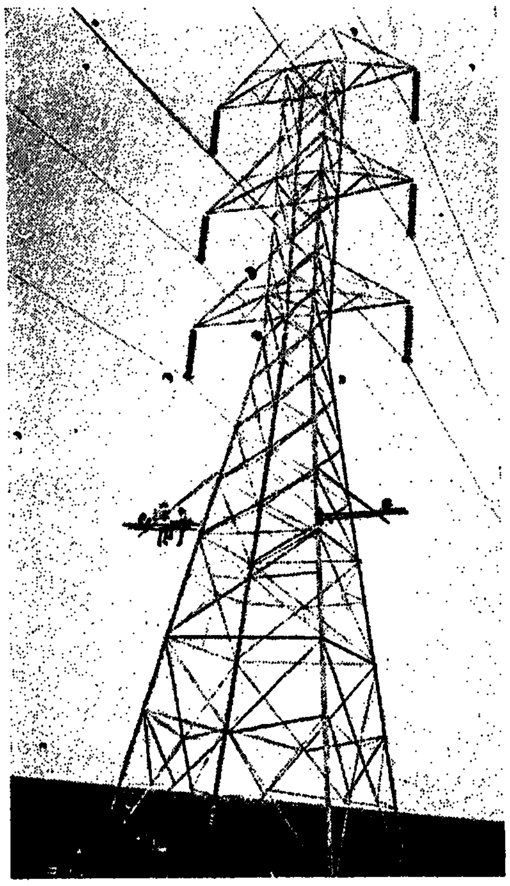

**Fig. 1. Mounting of recorders on a tower line having one aluminum and one copper circuit**

Records were taken while the lines were in operation (the aluminum line at 165 kv and the copper line at 220 kv) by placing the instruments on platforms 20 ft beneath the lower conductors to which the recorder actuators were connected at points about 6 ft from the suspension clamps by means of special cords. Conductors: A.C.S.R., 795,000 cir mil, 1.093-in. diam; copper, 509,400 cir mil, 4CS hollow core, 1-in. diam

Most of the testing was done on an aluminum line consisting of 3 795,000-cir-mil steel core aluminum cables having a conductivity equal to 500,000-cir-mil copper, and strung as one circuit on a double circuit 220-kv tower line. On the opposite sides of the same towers there are 3 hollow core copper cables of 1-in. diam having a section of 509,400 cir mil. The 2 sets of cables are parallel, with only 27-ft horizontal separation; they have the same ground clearance and hence have the same sag, and are supported in the same manner. Therefore, all spans are alike. This line represents almost ideal conditions for the checking of relative vibration on these 2 types of conductors.

A study of the relative vibration of the 2 types of conductor was undertaken and vibration recording equipment to take simultaneous records was installed and arranged as shown in Fig. 1. Observations were made for several weeks at a time when conditions were rather favorable for vibration. The data from the field tests are shown clearly in Fig. 2, where it may be observed that the copper and aluminum cables vibrated at approximately the same time. Loop lengths were observed to be of the same magnitude and the conductors vibrated at approximately the same frequency, but the amplitude of vibration of the copper conductors was less, as may be noted.

There is one other point to which attention should be called in connection with the vibration of transmission line conductors. Vibration in general occurs during the night hours, late in the evening, or quite early in the morning; the wires seldom vibrate during the usual working hours of the day. This point has led some engineers to believe their lines free from vibration.

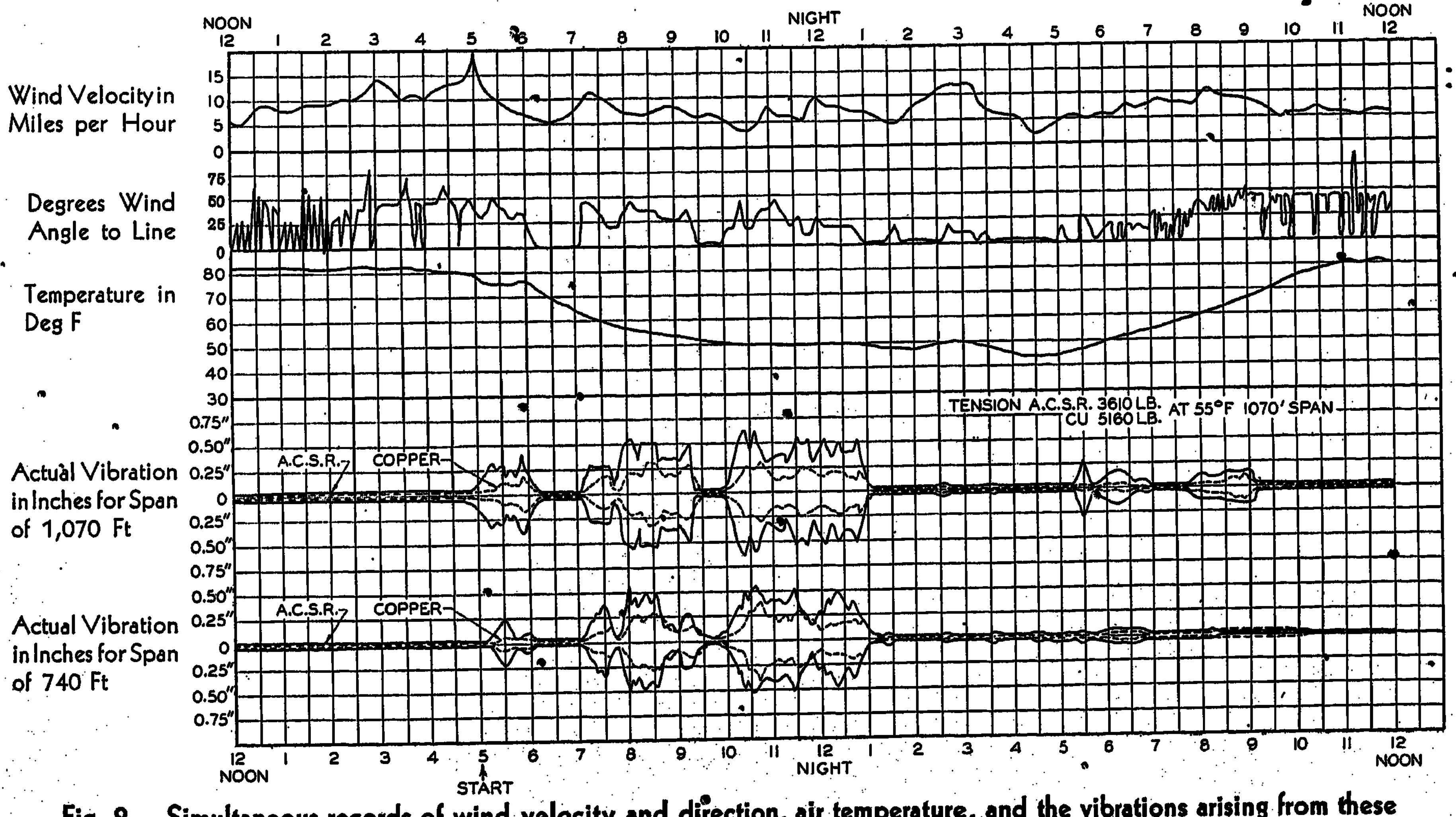

**Fig. 2. Simultaneous records of wind velocity and direction, air temperature, and the vibrations arising from these conditions in parallel copper and aluminum conductors. Smoked chart records were taken through a 24-hr period beginning at 5 p.m., May 8, 1932**

# Adult Technical Education in Metropolitan Areas

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**A plea for careful study of the advantages to be gained through properly coordinated efforts in, and facilities for, intermediate technical education and postgraduate work.**

PROFESSIONAL progress of our engineering societies has been and always will be influenced by the education of their members. Whether that education is recognized by professional degrees or is secured through pursuit of non-academic technical instruction is unimportant. It is, however, of interest and importance to know about the agencies contributing to the training of the potential professional engineering group, and how they may be made more effective in meeting the demands of this group.

In recent years through the investigation made by the Society for the Promotion of Engineering Education, attention has been directed to the entire system of engineering education. During the past year the educational committee of the Institute has given consideration to many of the problems brought forth by these and other studies. Affecting all of these problems is a general educational movement that for some time has been gaining in importance, but which only recently received organized recognition in the form of "adult education." It is the purpose of this paper to point out some of the possibilities in the development of adult education as they affect technical education and the providing of technical employees for industry.

## Supply of Engineering Graduates

In recent years, the employment of college graduates has been of no small concern. Figure 1 shows clearly what has taken place from the days of intense competition, 1924–29, up to the present time, when satisfactory employment is almost impossible. While this situation is of concern today, it is quite possible that the next 5 years will see a recurrence of the conditions that existed 5 years ago, for it is apparent that business conditions affect freshmen enrolments, with graduations reflecting these conditions 4 years later.

Whatever the situation may be, it is important to have some idea of the long term needs for engineering graduates as compared with the supply. An attempt in this direction was made by the National Industrial Conference Board a few years ago in a study of typical industries that seemed to show that 40,000 technically trained men could be absorbed by industry each year. This does not mean only professional engineering graduates, but includes all men with technical training. The recent study of technical institutes seems to show that from 40,000 to 50,000 men with intermediate training can be absorbed in normal times by industry, trade, and technical services. It is further stated that the ratio of engineering graduates to this group is approximately 1 to 3, which fact indicates that the present supply of engineering graduates should nearly meet the normal needs.

The normal demands for men with training perhaps equivalent to only half that of the 4-year undergraduate course do not seem to be met by schools established for that definite purpose, for the supply from this source is only approximately 1,500 a year. However, there are 15,000 non-graduates of engineering colleges each year who drop out of school and go to work in industry, not all of whom, by any means, lack adaptability to technical pursuits. Also, there are thousands of high school and vocational school graduates who, after entering industry directly from such schools, continue study in evening technical schools.

In 1930, out of 111 engineering colleges, 22 reported a total of 16,000 students enrolled in evening courses, of which number about half were studying for engineering degrees, while 1,760, or 11 per cent, were receiving credit toward advanced degrees. Among the evening school students are many of the group of non-college graduates who have dropped out of day school. Although records indicate that only a few of them ever will receive engineering

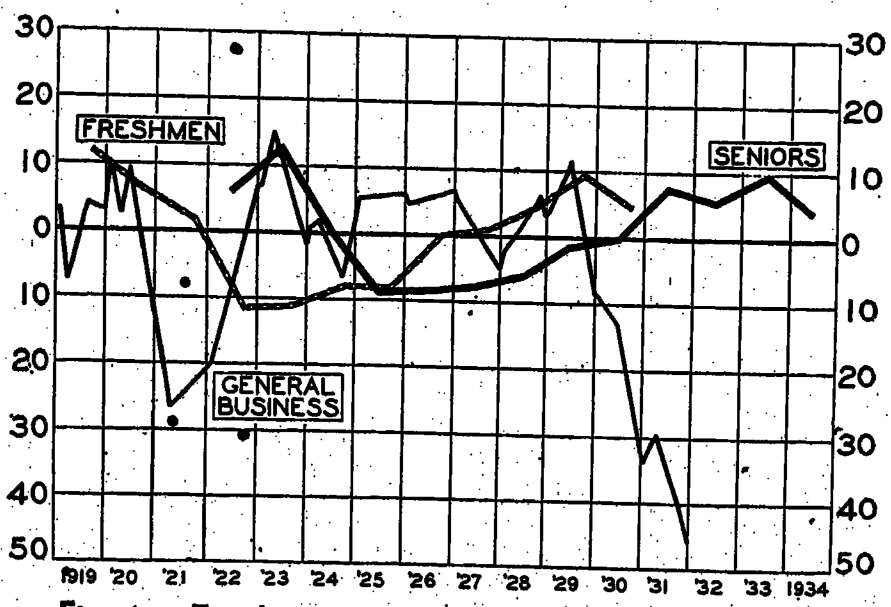

Fig. 1. Enrolment in engineering colleges and volume of general business as compared with "normal"

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Based upon a paper presented informally at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932. *Not published in pamphlet form.*

degrees, a sufficient number of them are adaptable to technical careers and meet a substantial part of the requirements of industry.

### Importance of Evening Educational Facilities

It is a characteristic of our 145 undergraduate engineering schools that many of them are located in relatively small communities, and that upon graduation their students migrate to the larger metropolitan and industrial areas. It is in these areas that the greatest possibilities are offered for the development of postgraduate instruction as well as other forms of engineering education, such as coöperative courses and intermediate technical instruction.

In the 1930 Census the United States Department of Commerce called attention to 95 metropolitan districts which it had established upon the basis of each having an aggregate population of 100,000 or more, and containing one or more central cities of 50,000 or more inhabitants. (Fig. 2.) In these districts is approximately 44 per cent of the total population of the United States. It is safe to say that more than $^3/_4$ of all engineering graduates are located in these areas. The question naturally arises as to the educational facilities, activities, and future needs of these areas. In the development of plans it would seem fairly fundamental to make a scrutinizing study of each district, bearing in mind the achievement of the fundamental objective of providing variety in training along with opportunity for professional development.

The successful development of facilities appropriate to each area, although depending largely upon the educational leaders of established institutions, will likewise need the support and cooperation of industries; at least to the extent of their making known the nature of their employment and training requirements, and stimulating their employees to take advantage of such educational courses as may exist. It would seem that the establishment of a well balanced program should include:

1. A study of the nature of the industries and occupations in the area considered.
2. Promotion of an effective system of vocational training in addition to academic high school education.
3. Establishment, where justified, of appropriate facilities for intermediate technical instruction of both the technical high school and the institute type.
4. Development of existing professional engineering schools.

The importance of a well balanced program is recognized, of course, but in only a few instances has any particular attention been given to the technological aspects of it.

### New York Studies

In New York 2 significant studies are in progress: one conducted by the Board of Education has to do with vocational education; the other is entirely independent, and is concerned primarily with evening technical education. The latter study is being conducted by the committee on commercial education of the Chamber of Commerce of the State of New York. A full report of this survey will be published in the fall of this year and should prove of interest to educators and industrialists. The main objective of the report is to ascertain the facts concerning the present facilities for adult technical education in the New York industrial area, and the purposes, results, and needs for education in this field.

### New York Educational Facilities

The 1930 census established the New York industrial area as including a population of 10,901,424, or slightly less than 9 per cent of the total population of the country. For the purposes of the Chamber of Commerce survey, the area considered is approximately the same as this district and includes 6 counties in New York and 6 counties in northeastern New Jersey.

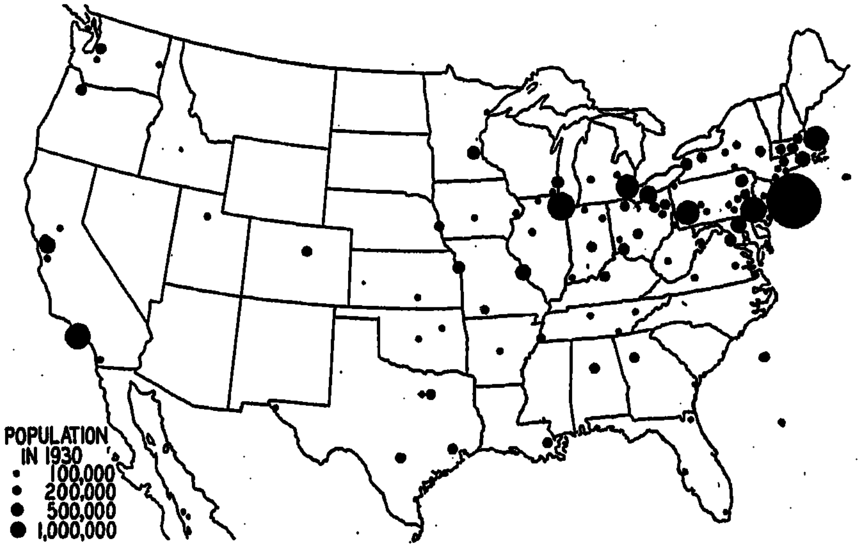

**Fig. 2. The 95 "metropolitan" districts listed by the U.S. Department of Commerce based upon the 1930 census**

In this area the schools and colleges giving some form of education associated with or preliminary to technical instruction include 12 engineering colleges and technical institutes of which 9 offer evening instruction, 4 evening schools of the Y.M.C.A. offering technical instruction, 25 public evening trade and vocational schools, and 32 private evening trade and vocational schools. The 9 engineering schools or institutes offering evening instruction are the agencies for primary consideration.

### Enrolment in Evening Technical Courses

In the 9 colleges and technical institutes offering evening courses approximately 10,000 students are enrolled; another 25,000 are enrolled in either trade or vocational schools. The distribution of enrolments by courses is shown in Table I, and may be taken as an indication of the relative demand.

Of special interest is the group of students enrolled in the 9 colleges and technical institutes. The 13,660 course enrolments studied covered only 8,000 of the 10,000 students enrolled, but were so taken as to be representative of the group. An effort was made in the survey to study the type of students enrolled, and their industrial employment. About $^2/_3$ of the students were found to be between 19 and 26 years of age, although it is significant also that many were men occupying substantial positions in industry.

A study of the educational preparation of these students indicates that about 80 per cent had a high school education or better, about 33 per cent had gone to college, whereas less than 10 per cent were college graduates. This latter figure, while small in comparison with the entire group, represents from 800 to 1,000 college graduates, and is evidence of considerable interest in further education.

## GRADUATE STUDY

Up to the present school year the only evening colleges offering recognized degree-granting courses in engineering were New York University, The Polytechnic Institute of Brooklyn, and the College of the City of New York. These courses require from 6 to 10 years for completion. Only one of these schools, The Polytechnic Institute of Brooklyn, offers degree-granting postgraduate courses. The development of this work by the Polytechnic Institute is of considerable importance, for many college graduates yearly find employment in the New York area and look for opportunity for further study there. Prior to 1925 only a few miscellaneous courses of the graduate level were offered at Brooklyn Polytechnic Institute.

The development of evening graduate study doubtless will be followed with considerable interest, for it suggests an effective means for the engineer to continue his education after graduation, and offers also a solution to the economic problem of financing graduate study after a considerable investment already has been made for undergraduate work.

**Table I—Summary of Enrolments in Technical Courses of Evening Schools in New York Industrial Area**

| Subjects | Colleges and Technical Institutes | Y.M.C.A. Schools | Private Trade or Vocational Schools | New Jersey Public Schools: Vocational or Trade | New Jersey Public Schools: High and Elementary With Indust. Subj. | New York Public Schools: Vocational or Trade | New York Public Schools: High and Elementary With Indust. Subj. | Total |
|---|---|---|---|---|---|---|---|---|
| **Architecture** | | | | | | | | |
| Arch. Engg. | 11 | | | | | | | 11 |
| Bldg. Eqmt. & Constr. | 221 | | | | | | | 221 |
| Design | 218 | | | | | | | 218 |
| Drawing & Drafting | 1,760 | 13 | 30 | 404 | 35 | 400 | 55 | 2,697 |
| Hist. of Arch. | 69 | | | | | | | 69 |
| Plan Reading & Est. | 363 | 7 | | 57 | 24 | 249 | | 700 |
| Total | 2,642 | 20 | 30 | 461 | 59 | 649 | 55 | 3,916 |
| **Engineering** | | | | | | | | |
| Aeronaut. Engg. | 6 | | | | | | | 6 |
| Chem. Engg. | 300 | | | | | | | 300 |
| Civil Engg. | 1,263 | | | | | | | 1,263 |
| Drawing & Drafting | 219 | | | | | | | 219 |
| Elec. Engg. | 1,600 | | | | | | | 1 600 |
| Heat. & Vent. Engg. | 20 | | | | | | | 20 |
| Indust. Engg. | 80 | | | | | | | 80 |
| Mech. Engg. | 1,565 | | | | | | | 1,565 |
| Prep. & Elem. | | | 8 | | | | | 8 |
| Total | 5,053 | | 8 | | | | | 5,061 |
| **Mathematics** | | | | | | | | |
| Elementary Math | 1 778 | 75 | 2 | 228 | 57 | 413 | | 2,553 |
| Advanced Math | 1,275 | | | | | | | 1,275 |
| Total | 3,053 | 75 | 2 | 228 | 57 | 413 | | 3,828 |
| **Physical Sciences** | | | | | | | | |
| Chemistry | 765 | 19 | | 133 | | 47 | | 964 |
| Geology | 17 | | | | | | | 17 |
| Metallurgy | 34 | | | | | | | 34 |
| Mineralogy | 3 | | | | | | | 3 |
| Physics | 1,203 | 16 | | | | 74 | | 1,293 |
| Total | 2,022 | 35 | | 133 | | 121 | | 2,311 |
| **Trades & Voc.** | | | | | | | | |
| Trade & Voc. Subj. | 1,275 | 531 | 2,016 | 4,428 | 777 | 9,635 | 1,463 | 20,125 |
| Grand Total | 14,045 | 661 | 2,056 | 5,250 | 893 | 10,818 | 1,518 | 35,241 |

## NATURE OF NEW YORK INDUSTRIES

In a metropolis such as New York the question of the adequacy of local technical education is advanced periodically, either by civic associations, educational bodies, newspapers, or other interested groups. A suitable approach to the answer to questions relating to demand, utilization, and encouragement of technical graduates would seem to be a systematic investigation of the industries in each of the large metropolitan areas, with the objective of establishing or developing such educational agencies as seem necessary to meet industrial requirements.

In most industrial concerns the most important requirement is to impart to the individual sufficient technological information about the process he handles to enable him to conduct his work intelligently. Because such training usually takes the form of single process instruction to the individual, it is not concerned with education of college or professional grade. It is a serious question, however, as to how much technological instruction can and should be given technical workers and minor supervisors. Since technical instruction is an instrument of industry and its place and usefulness is confined almost entirely to industry, there would seem to be a field in technical education which should aim to supply such scientific courses as would aid the individual to a better understanding of technical processes. What these subjects are must evolve largely from a study of industry.

New York is commonly looked upon as an area of large industrial establishments. However, the fact is that aside from about 3 dozen large manufacturing companies employing on an average 2,233 employees, and a group of 1,700 companies of intermediate size employing on an average 292 employees, each of the remaining 34,000 companies employ less than 100 individuals, and average only 16 per establishment. The large manufacturing companies employ only $6^1/_2$ per cent of the total; and the small companies 50 per cent. These facts would seem to indicate considerable difficulty in training substantial numbers within industry, and almost a necessity for some outside agency to provide technological training either prior to the individual's employment or through evening education for those employed.

In connection with New York evening school enrolments it is of interest to observe that fully 3 times as many students are enrolled from the service industry group as from the manufacturing industry, although the latter employees number almost 50 per cent more than service industry employees.

The service industries include public utilities, city employees, architects and consulting engineers, building industries, cleaning establishments, and garages. The public utilities are large, well established companies with training requirements for the most part cared for internally. Their employees, however, in comparison with those of the manufacturing group, seem to show more interest in professional technical courses, as do also the employees of the city and professional engineering establishments. This manufacturing group looks more to the professional schools of engineering for recruiting its future technical personnel.

## DEMAND AND NEED FOR TECHNICAL EDUCATION

From preliminary observation it would seem that there is need for variety in technical education; and that the development of adult or evening instruction in metropolitan areas offers a partial solution in meeting the need not only for the intermediate type of training, but also for the graduate instruction of the engineer. This is a subject of interest to all of us. However, the demand as manifested by the interest of employees in industry is not so evident. This may be due to any or all of the following causes:

1. Facilities are not always conveniently available.
2. The proper incentive has not always been given through definite educational and training policies on the part of management.
3. Unit courses are not developed sufficiently for maximum benefit to the employee.
4. Anything less than the conventional 4-year college course seems not quite reputable nor acceptable to those to be trained, perhaps because of the feeling that such training might limit their life achievement to specific fields and levels less remunerative and esteemed than those attained through the 4-year college course.

From an industrial point of view, there is little or no justification for the latter conclusion, for in the industrial and service group in the New York area alone, there will be in the next 10 years at least 150,000 positions of suitable responsibility available. How many of these should be occupied by technical graduates is not known, but it is safe to say that the majority of them will be filled by men of less than college graduate training, whose chances would be greatly improved if they were in training today.

This article is presented for the purpose of calling to attention a possibility which if followed to a logical conclusion, holds promise not only of improving the professional status of the engineer, but also of causing a more sane adjustment of technical workers to acceptable vocations. In its fundamentals it means a study of the world's work and the acceptance of the philosophy of the concurrent pursuit of educational improvement and gainful occupation.

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# Double Conductors for Transmission Lines

**Two overhead conductors a few inches apart used for each phase of a transmission line circuit reduce the reactance 20 per cent or more, thus, in many cases, increasing the power rating of the line. Also current carrying capacity and corona voltage limits are increased. However, costs with this type of construction are higher than with one larger conductor per phase. In addition to describing the advantages and disadvantages of double conductor lines, formulas are given in this article for the calculation of the electrical characteristics.**

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DOUBLE conductors transmission lines, that is, lines employing 2 overhead conductors for each phase instead of the usual one for each phase, present a number of advantages. These advantages must be balanced against the extra cost due to mechanical features, including hangers, increased cost of stringing and additional wind and ice load. The construction is the same as in the usual transmission line except that a second conductor is run a few inches below the first by metallic hangers, similar to those used in electric railway catenaries. The 2 conductors therefore are electrically in parallel and form one effective conductor of large cross-section without increasing the number of insulators or crossarms.

## REACTANCE

An overhead double conductor line has approximately 20 per cent less reactance than a single conductor line of the same weight of conducting metal. In many usual cases, especially where there is not complete control of the voltage by synchronous condensers, the reactance is the most important item in determining the power rating of the line, for both the voltage drop and the stability limit of the load

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Based upon "Double Conductors for Transmission Lines" (32-99) presented at the A.I.E.E. North Eastern District meeting, Providence, R. I., May 4-7, 1932.

depend principally on the reactance. Therefore, in many instances, without increasing the weight of conductor metal, a line can be built for about one-fifth greater power rating at very little increase in cost where ice load is absent, by using double conductor construction. This is particularly advantageous where the cost of the right-of-way is large, and is is desirable to transmit as much power per circuit as possible.

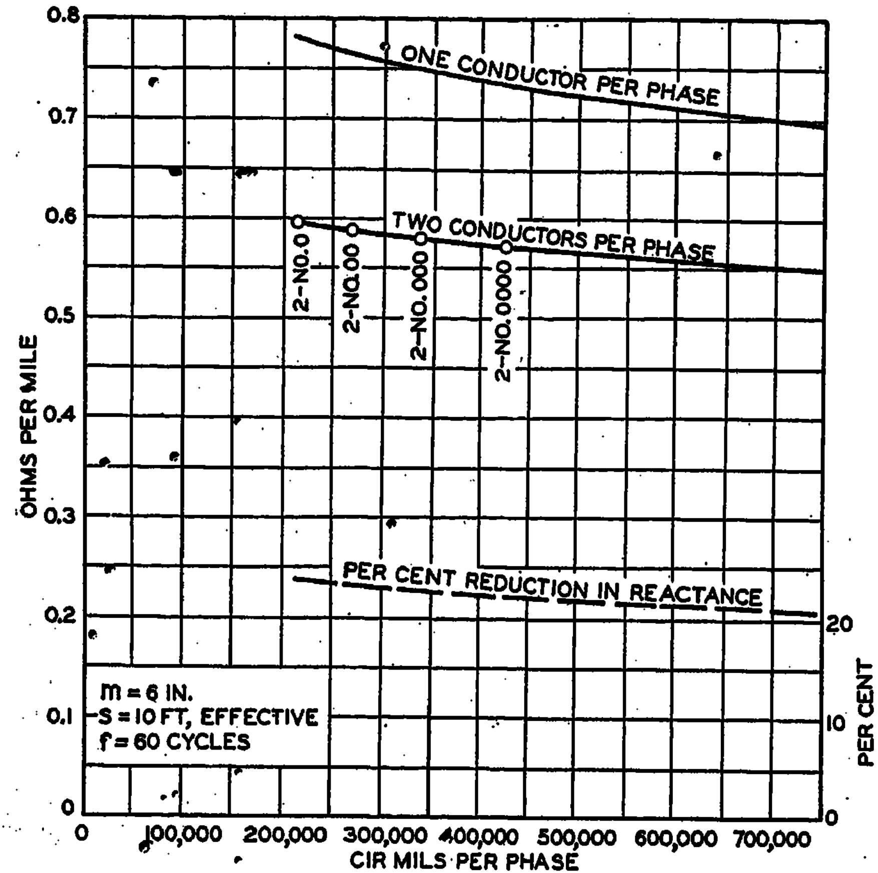

**Fig. 1. Comparison of reactance of single and double lines for different conductor sizes**

In Fig. 1 is shown graphically the reduction in reactance, amounting to approximately 20 per cent on practical lines, obtained by using double conductor construction. The formula for the reactance of a double conductor line, suitable for usual overhead spacings and for round wire, is

$$\text{Reactance} = \pi f 10^{-6}\left(80.5 + 741 \log_{10}\frac{s^2}{m\rho}\right) \text{ ohms per mile} \qquad (1)$$

where

$f$ = frequency
$s$ = geometric mean radius of the spacings between the phases
$m$ = separation of the 2 wires per phase
$\rho$ = radius of the conductors

If the conductor is a 7-strand cable of diam $2\rho$, the figure 80.5 is changed to 103.3 and if there are 19 strands, the figure becomes 89.3. (See reference 9, p. 127, for other numbers of strands.)

Fig. 1 is drawn for copper conductors. It may be noted that hollow conductors and aluminum conductors of equivalent resistance have from 5 to 7 per cent less reactance than the values shown for single conductors in Fig. 1. The 2 small conductors of the double conductor line may be of aluminum if desired.

The effect of changing the distance between the 2 wires of the same phase, in a double conductor line, is shown in Fig. 2. It is seen that for spacings larger than 6 in. there is little further improvement. Accordingly the discussions in this paper for the most part are based on a value of 6 in. Curves for other conductor sizes and for other spacings between phases are very much the same as the curves of Fig. 2.

## Resistance

Another limit to the power rating of a transmission line is the cost of resistance losses. The greatest advantage of double conductor construction in this connection is in the case of a line already built, which has higher resistance than desired and which has some mechanical margin of safety. It is possible to add a second conductor and cut the resistance in half without the necessity of taking down or scrapping the old conductor. In other words it is possible to make the reduction in resistance with only one-half as much new conductor metal as would be needed if single large-size conductors were installed. It is, of course, necessary that the line be strong enough to stand the extra weight including wind and ice on the second conductor. The proposition to add to the conductor metal of existing lines may be attractive at a time when the cost of conductors per pound is low.

For new transmission lines the difference in resistance between single and double conductor lines of a given weight of conductor metal is due to skin effect. The amount of the difference is shown in Fig. 3. It is seen to be a matter of minor importance with overhead conductors of usual sizes. For obtaining values of skin effect of hollow conductors, see reference 1.

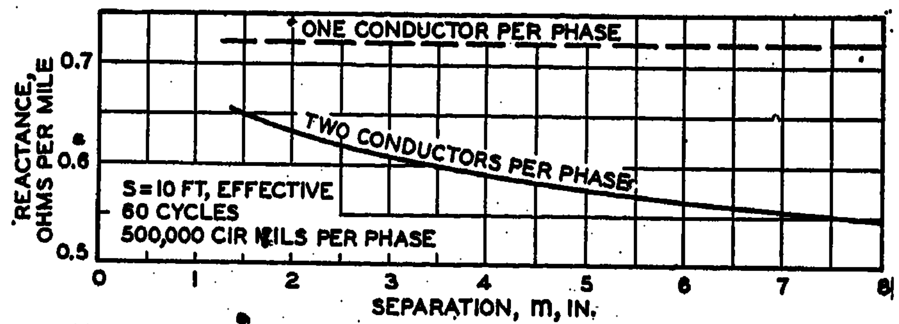

**Fig. 2. Change of reactance with separation of paralleled conductors**

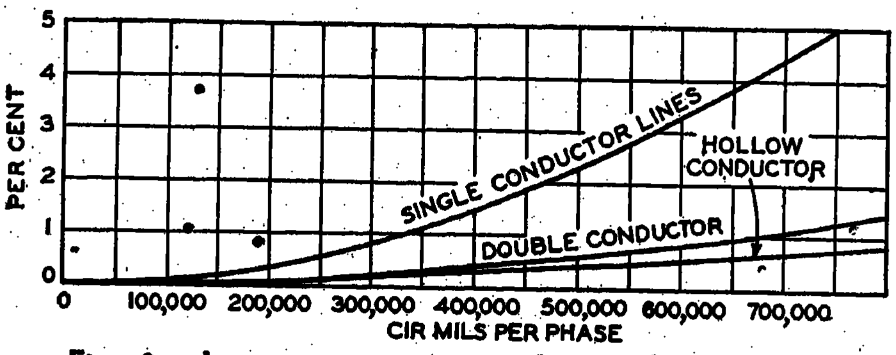

**Fig. 3. Increase in resistance due to skin effect at 60 cycles**

## Heating of Conductors

In the preceding 2 paragraphs the cost of resistance losses was considered as a limitation to the allowable power load of a line. With some short lines, and notably with many tie-lines, voltage drop and the cost of resistance losses are not serious limitations to the allowable load, and heating of the overhead conductors is the practical limit encountered. In many cases, twice the normal load must be carried by one circuit as an emergency condition. Annealing of the hard-drawn copper and oxidation of joints in connectors are reasons for keeping the conductor temperature down.

Tie lines have been built with very heavy overhead conductors for the purpose of avoiding overheating of the conductors. A 132-kv, 30-mile tie line from Chicago, Ill., to Waukegan has been built with 750,000-cir-mil hollow copper conductors. It is stated in reference 6 that the main condition in designing the line was the heavy current to be carried.

The curves of Fig. 4 have been drawn from the table of current ratings published in reference 3, p. 466, for bare conductors, outdoor service, and 40 deg C rise. It is seen that double conductor construction increases the current carrying capacity nearly 30 per cent for a given weight of conductor metal. This is because the 2 small conductors have more surface than the single large conductor. If current ratings from the table for indoor service were used, the percentage difference between single and double conductor construction would be nearly the same. Hollow copper conductors, because of their large diameter, show an increased current carrying capacity over corresponding standard cables, though the increase is usually a small percentage. Aluminum conductors also have larger diameter and therefore greater current carrying capacity than standard copper cables of the same resistance.

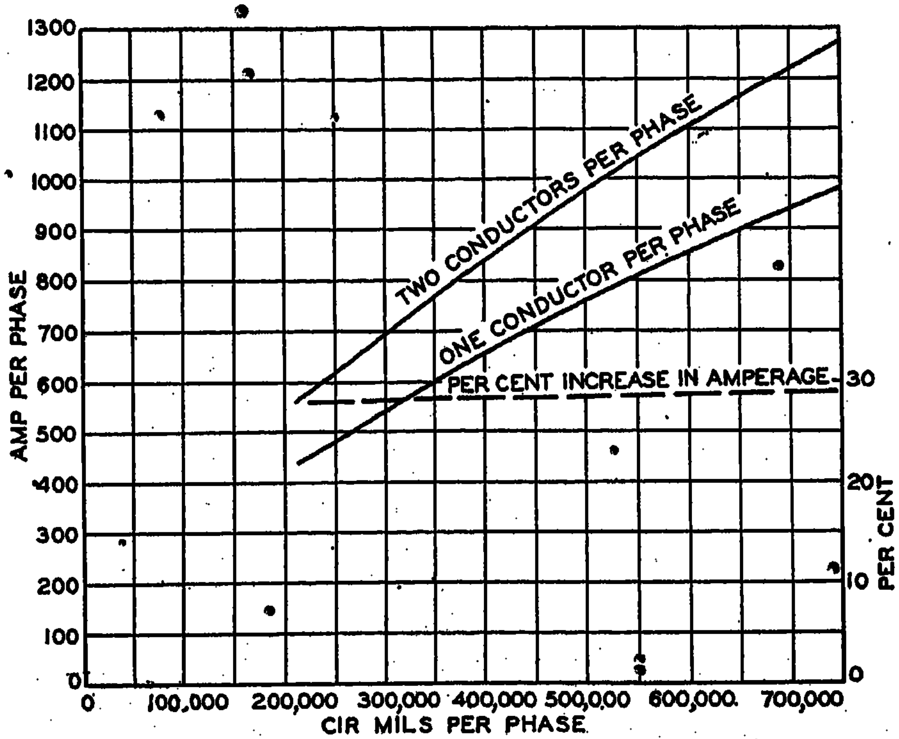

**Fig. 4. Current carrying capacity of bare conductors for outdoor service with 40 deg C temperature rise**

CAPACITANCE

As is shown by Fig. 5, the capacitance of an overhead double conductor line is 20 per cent or more greater than that of a single conductor line of the same weight of conductor metal. This is an advantage in the case of power networks in well-settled parts of the country where the loads and generating stations are scattered to some extent throughout the network. In such networks it is a matter of experience that synchronous condensers are used almost entirely with strong field currents, and very few with lagging power factor load and weak field currents. Consequently, an increase in line capacitance of 20 per cent means a saving of a definite amount of synchronous condenser capacity which would otherwise need to be installed.

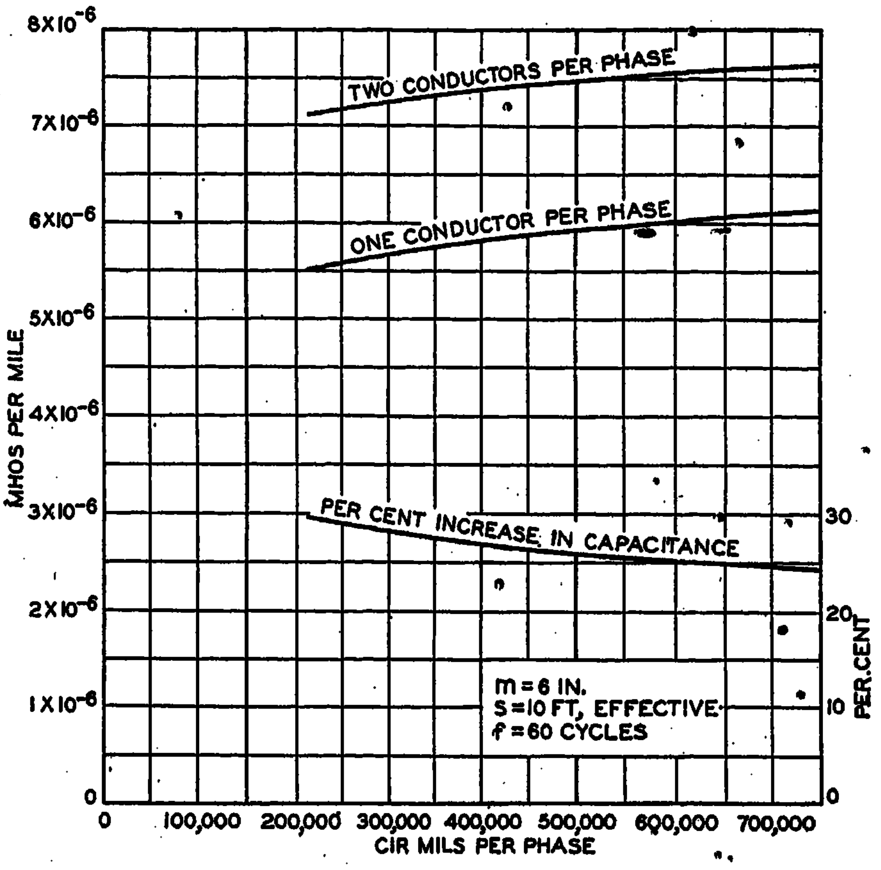

**Fig. 5. Comparison of capacitive susceptance of single and double conductor lines**

In other cases, where transmission lines are very long and the loads are widely separated from the generators, special attention is required to handle the line capacitance current. A sufficient number of generators must be kept always connected to the system, so that the no load current is not an overload for them and so that the field current at rated voltage and leading power factor load does not become so small as to endanger the stability of the system. While these matters require attention, yet they seldom involve expense, particularly in the case of water power systems where they are most likely to be noticeable, for there are practically always plenty of generators available. Accordingly even in such cases an increase in line capacitance by using double conductor construction is not an economic disadvantage.

The formula for capacitive susceptance of a double conductor line of usual capacity is

$$b = \frac{4\pi f\, 38.8 \times 10^{-9}}{\log_{10} \dfrac{s^2}{m\rho}} \text{ mhos per mile} \qquad (2)$$

CORONA

Values of corona voltage, that is, the voltage at which corona starts, are shown in Fig. 6 for 1 and 2 conductors per phase, where $m$, the separation of the 2 conductors of the same phase, is 6 in. Very little increase in corona voltage is obtained by using 2 small conductors of the same type as the single large one. This is in general true at separations other than 6 in. More increase in corona voltage is obtained by using 3 or more conductors per phase. The use of a hollow or cored conductor gives a considerable increase in corona voltage.

Measurements of the corona voltage with 2 and 3 transmission line conductors per phase are given in reference 8, p. 82, and also in the first edition of the same book, published in 1915, p. 71 and 72.

If a double conductor line and a single conductor line have the same calculated corona voltage, the operating voltage of the double conductor line should be kept lower than that of the other, because when corona does start, as in stormy weather, the double conductor line has twice as many conductors on which loss takes place.

The formula for corona voltage of a double conductor line of usual spacing, assuming an average irregularity factor $m_0$ of 0.85, is

$$e_o = 105\,\rho \log_{10} \frac{S}{\rho} \qquad (3)$$

A number of features relating to the use of 2 and 3 conductors per phase are discussed in reference 7. In this work a rather large spacing between the paralleled conductors, namely 18 in., was assumed.

## Mechanical Features and Costs

A transmission line with 2 conductors per phase could be constructed using a type of hanger already developed and tried out for electric railway catenaries. It would be more expensive than a single conductor line of equal mechanical strength. The duty on the towers, and their height, would be greater due to approximately twice as much wind and ice load. More clearance would be required and shorter spans might be needed. More margin of safety would be required in the tensile strength of the conductors, for although each might be pulled up to the proper tension, it would not be certain that one conductor would not take more than its share of the tensile load at some later time. The cost of stringing the conductors would be greater. Since the increase in ice load is perhaps the greatest disadvantage, the use of double conductors is of most interest for southern districts, where ice load is not encountered.

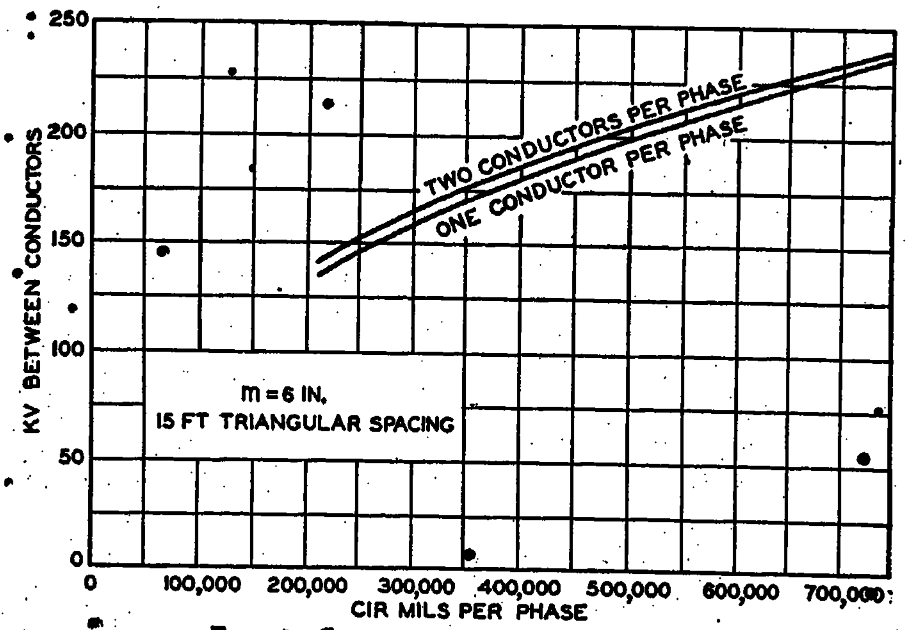

Fig. 6. Corona voltage at sea level

The additional cost due to the mechanical features of the double conductor construction is to be balanced against the value of the advantages to be obtained. If circumstances are such that the voltage drop in the line must not be more than a certain percentage, then 20 per cent reduction in reactance permits a corresponding increase in the allowable power load. In such a case the additional cost is to be compared with 20 or 25 per cent of the entire cost of the transmission line. This assumes that methods of controlling the voltage, as by synchronous condensers, are not considered applicable, and that the only way in which the power can be increased is by decreasing the reactance or providing additional circuits.

An increase in current carrying capacity or in corona voltage might be an additional advantage, but such an increase would probably not by itself justify the special construction, for ratings now in use. The current carrying capacity or corona voltage of a single conductor line could usually be increased 30 per cent without increasing the cost of the entire transmission line more than a few per cent, by using a heavier conductor or one of about 30 per cent larger diameter. The cost of the conductors is only a fraction of the cost of the entire line. Such a conductor, however, will not give 20 per cent less reactance. The large reduction in reactance is therefore the most important feature of the double conductor construction.

In conclusion, the advantages shown are as follows: Approximately 20 per cent less reactance; the opportunity in some cases to add to the conductivity and power rating without scrapping the old conductors; the almost entire elimination of skin effect; and the increase in current carrying capacity of nearly 30 per cent. The disadvantages are the greater clearance and mechanical strength required, particularly where ice load is important, the cost of hangers, and the increased cost of installation.

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# The Significance of Noise Measurements

**Dirt has been defined as being matter out of place; likewise noise may be regarded as misplaced sound. Sounds that are attractive musical notes under one circumstance may be distressingly annoying under other conditions. Present knowledge of noise and its effective control is summarized here.**

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SOUND is a general name for anything that is heard including music, speech, and various kinds of noise. The word "noise" implies annoyance, and includes: such separate disturbances as hammer blows, footsteps, or the slam of a door, many sustained tones which would be considered under some circumstances to be musical, the complex sounds emitted by almost all kinds of machinery, and music and speech when considered as a disturbance of the hearing sensation (that is, when the reception of that particular music or speech is not desired by the listener).

"Noise" also refers particularly to the complex disturbance caused by a group of people talking independently, as an audience does before a meeting is called to order, or any other complex jumble of disturbances perceived by the sense of hearing. In factory or office buildings there is a surprising amount of this complex disturbance which is the combined effect of people talking and moving about, various pieces of machinery operating in different parts of the building, the operation of typewriters and ventilating fans, water running in pipes, and so on. In a busy street there is much noise of this sort, the effect of many different causes.

## Simplest Sound a Pure Tone

The simplest sound is what is known as a "pure tone." A pure tone has both intensity (amplitude) and frequency (pitch), and consists of a regular motion of the particles of air which lie between the source and the listener. By virtue of this motion the pressure of the air at any particular point becomes (many times per second) alternately greater and less than the average. The frequency of this alternation is the frequency or pitch of the sound. To be strictly accurate, the manner in which the pressure changes at any point as a function of time must be what is known as sinusoidal variation if the tone is to be a pure tone.

If the variation of pressure with respect to time is not sinusoidal and yet is regular to the extent that the complete mode of variation is continuously and exactly repeated (many times per second) the sound is what is called a "musical tone." The effect is the same as if several pure tones (each having a frequency which is a multiple of the fundamental frequency) were produced and heard simultaneously. When such an equivalent set of pure tones is identified, the "musical tone" is spoken of as having been analyzed into its components—the "fundamental" and the "harmonics." The difference recognized when the same "note" is played on different musical instruments arises from the different wave shapes or modes of vibration of the air when set in motion with the same fundamental frequency by the different instruments. This usually is expressed by saying that different instruments have different timber or quality or that they give rise to tones in which the different harmonics (or overtones) differ in strength.

The noise emitted by some machinery may be practically a "musical tone" as that term has just been defined. Many machines, however, emit noises which are the equivalent of several simultaneous "musical tones." The fundamental frequencies of these several components may bear no simple relation to one another, and the result is what would be called discord in music; but this aspect of the matter perhaps is overshadowed in the mind of the listener by the effect of the persistence or repetition of the particular combination of sounds, a disagreeable effect never attempted in music.

Music and speech, when regarded as noise, differ from the noises usually made by machinery in that they change rather rapidly their characteristics of frequency and amplitude. That is, during the brief time that any particular note (in music) is being held, or for the duration of a particular sound such as a vowel sound (in speech), the sound may be analyzed into component "pure tones"; but very soon, as the music goes on to the next note or the speech goes on to the next speech element the set of component pure tones is changed. During the transition from one note to another or from one speech element to another the motion of the air particles may not at all correspond to periodic motion.

If many people are talking at once the number of frequency components in the resulting noise becomes so great that, so far as the analytical apparatus of the ear (or of most physical measuring apparatus) is concerned, components of *all* frequencies over a wide range are present. Of course the detailed conditions change rapidly, but if the number of voices involved is large there is established a sort of dynamic equilibrium which is registered by the ear as a fairly constant noise. Conditions similar to this may arise from other causes. The noise of "air rush" from a fan or near any rapidly moving piece of machinery, apparently because of the rapidly shifting arrange-

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Essentially full text of a paper presented before the A.I.E.E. Lynn, Mass., Section, March 23, 1932. *Not published in pamphlet form.*

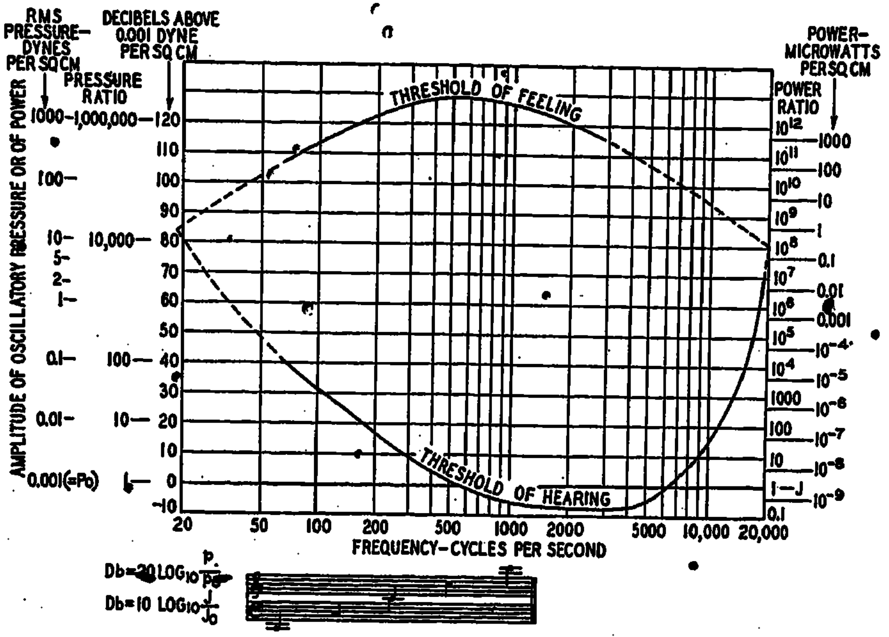

Fig. 1. Range of auditory sensation for the average human ear

ment of air eddies, seems to have this characteristic of indefinite frequency. Such a noise of course may include or be accompanied by component tones of perfectly definite and sustained frequency.

### Range of Human Perception

The "auditory sensation area" of the average human ear is shown in Fig. 1 where the abscissae represent frequencies plotted on a logarithmic scale. It may be noted that tones having frequencies anywhere in the range from 20 to about 20,000 cycles per second may be perceived by the ear. The limits differ widely for different individuals and there is a tendency for the upper limit to be reduced with increasing age of the observer.

Frequencies are plotted on a logarithmic scale for two reasons: (1) it accommodates conveniently the extensive range of frequencies involved, and (2) on such a scale the musical intervals such as octaves, fifths, and so on, which appear to have a rather fundamental importance in human comprehension of sounds are represented as equal intervals regardless of frequency. That is, the interval from 100 to 200 cycles per second is an "octave" as is also the interval from 2,000 to 4,000. The note represented in musical notation as "middle C" has a fundamental frequency just a little above 250 cycles per second.

The ordinates of Fig. 1 are values of the physical amplitudes of the tones at the ear of the listener. These may be indicated in several different units and may be expressed in terms of the pressure variation of the air or in terms of the power transmitted. The striking fact is the extreme range of amplitudes which may be perceived as sound, a range in the order of a ratio of 5,000,000/1 in terms of pressure variation or of $10^{13}/1$ in terms of power. For a diagram such as this to cover such an extensive range it is practically imperative to plot the values logarithmically, as has been done here. It is convenient in the practical work of measuring noises to refer to their amplitudes by a logarithmic scale such as the "decibel" scale. The "bel" or the "decibel" is fundamentally a unit of power ratio, and when used to state the amplitude of a noise the reference value of power (or the corresponding pressure variation) must be expressed or implied.

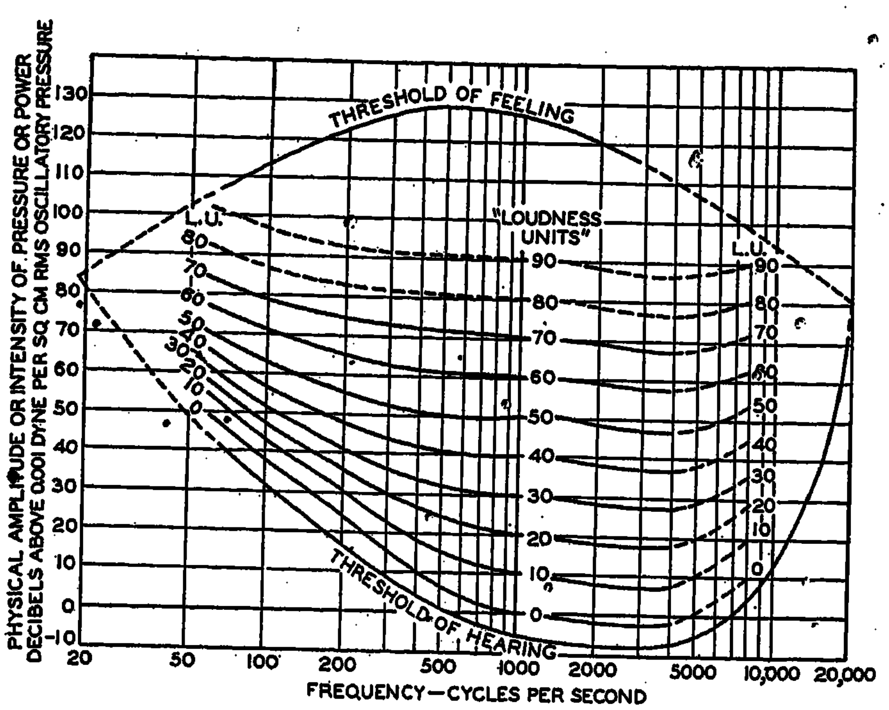

Fig. 2. Area of average human auditory sensation showing "equal loudness" contours

As a unit of noise measurement the decibel (db) has the practical advantage of being roughly the minimum change of amplitude which ordinarily can be detected, considering the whole range of audition. It is not by any means a perfect fit in this respect, but it is much better than any non-logarithmic unit would be.

### Comparison of Loudness

Figure 2 shows what are called "equal loudness contours" for pure tones. If a listener be asked to observe the difference in 2 different pure tones sounded one after the other he probably will be more conscious of a difference in frequency (pitch) than of a difference in loudness. This is because of our training, and the habit of associating noises with their sources. Noise is observed from a given source under widely varying conditions of loudness depending upon the distance from the source and upon the amount of absorbing material such as room walls between the listener and the source. The frequency of a note from a given source is subject to much less variation. It is the frequency of the noise, then, that is the more important clue to the interpretation of noises heard. (Usually complex sounds rather than simple tones are heard and the habitual association of sound with source depends upon several frequency components being heard simultaneously.) However, it is possible to decide which of 2 tones sounds the louder, provided there is sufficient difference between them, even though the 2 tones be of different frequencies.

From another point of view, given the proper physical equipment for producing sounds of varying amplitude, it is possible to make a sound which seems as loud as a 1,000-cycle tone of standard loudness. The "equal loudness contours" in Fig. 2 connect points representing tones which, from the average results of many such experiments, seem to impress the average observer as being of equal loudness.

Hence the position of a plotted point relative to these loudness contours is an indication of what may be called the "physiological loudness" of the corresponding tone. A numerical value may be given to the physiological loudness of a tone of any frequency by stating the physical amplitude of an equally loud tone of some standard frequency, say 1,000 cycles per second.

A musical tone, machinery noise, or other complex noise can be assigned a value for loudness in essentially this same manner by comparison with a pure tone of standard frequency adjusted to equivalent loudness and measured for physical intensity. This leads to the definition of the "loudness units" of any noise as the "decibels above 0.001 dyne per sq cm (rms oscillatory pressure)" of a 1,000-cycle pure tone which appears equally loud when the 2 sounds are compared. It would be very difficult to determine the loudness of an ordinary noise if a *direct* comparison really were required. The "noise meter" in effect makes this comparison, but what it actually measures is the amplitude of all the noise components, integrating their effect after weighting them according to their frequencies and the experimental data on equivalent loudness, considering the components as pure tones.

From a practical standpoint it is more important to know how annoying a noise from a certain source will be rather than to know how loud it is. This question goes beyond both the physical considerations of noise and the physiological question of loudness; it is a complex psychological question. Apparently the annoyance of a noise depends upon the loudness of its components and in a complex way upon their frequencies. Annoyance also depends upon circumstances, such as whether the noise seems the normal accompaniment of the work in hand or is distracting. A carpenter probably gets some sort of satisfaction out of a good clear "bang" each time he hits at a nail with a hammer whereas a disinterested neighbor may be severely annoyed by the same sound.

Reduction of the amplitude of the loudest noise components in a complex noise may be presumed to reduce the annoyance caused by that noise. The relative annoyance of two complex noises having different frequency components, such as the noises coming from motors of different design, involves questions of "masking" of one component by another, questions of discord between the several components, and questions concerning the relative annoyance of the different components considered as pure tones. Incidental observations made in the course of various noise investigations indicate that pure tones annoy different observers in a very different manner, considering annoyance as a function of frequency. However, that is a complex matter of psychological research which so far has not been investigated comprehensively.

## SOURCES OF NOISE

In considering briefly its production and distribution, sound, in the physical sense, may be considered as one form of power, quantitatively microscopic, transmitted through the air and other media. Usually the immediate source of the energy transmitted to the air is the mechanical vibration of some surface, such as the sounding board of a musical instrument or the vibrating surfaces connected with a piece of machinery. The discovery of the "cause" of a noise usually implies some further explanation of the connection between the vibrating surface and some more fundamental source or energy. A satisfactory explanation of a noise requires a knowledge of the fundamental energy source, the mechanism of transformation into vibration, and the means by which the vibration is transmitted to a definite "sounding board."

## NOISE MEASUREMENTS

Included in the term "noise measurements" are several different measurements including the determination of: the physiological value for "total noise," in "loudness units"; the frequencies of the principal components of the noise; and the physical amplitude or the equivalent loudness of the several noise components. Also, the closely related measurements of frequency and amplitude of mechanical vibrations involved in noise production may be included in the category of noise measurements.

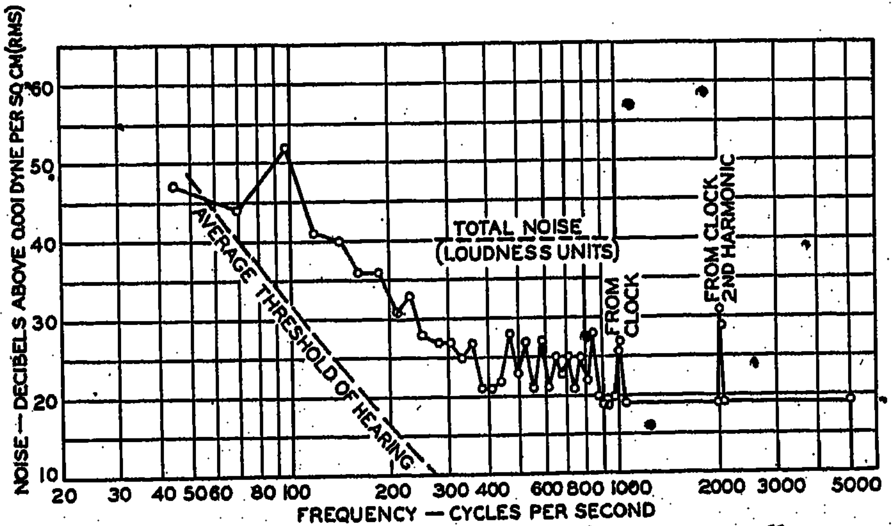

**Fig. 3. Analysis of room noise in a laboratory office**

The weighting to compensate for the differing response of the ear to different frequencies makes the "total noise" as measured in loudness units less in this case than the maximum noise as expressed in decibels. Readings were taken arbitrarily at each division of the analyzer frequency dial

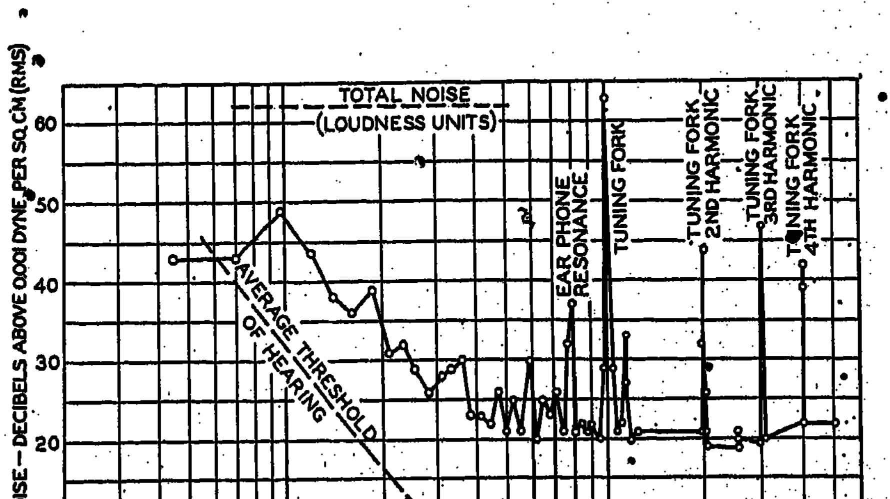

**Fig. 4. Analysis of the room noise of Fig. 3, as augmented by sounds from a 1,000-cycle tuning fork**

Results of noise measurements made in one particular room are shown in Fig. 3, plotted logarithmically the same as for the first 2 figures, except that the scale is somewhat larger and only a part of the auditory sensation area is shown. The noise in this case consisted largely of a jumble of various low frequency noises none of which were constant. The noise as a whole is equivalent in loudness to that of a 1,000-cycle tone of an intensity 40 db above 0.001 dyne per sq cm; that is, the noise is one of 40 loudness units. Because of the weighting of the total to compensate for the different sensitivity of the ear for different frequencies, the "total" is less in loudness units than some of the indefinite low frequency components as measured in decibels. The 2 small components of definite frequencies (1,000 and 2,000 cps) were readily identified as coming from a nearby clock connected to a piezoelectric standard for radio frequencies.

After observing the measurements of room conditions as shown in Fig. 3 further readings of the noise level were made at the same place after starting an electromagnetically driven tuning fork, the sound of which was brought to the vicinity of the microphone by means of a telephone receiver. This superimposed noise simulated a very simple machinery noise and produced the effects shown in Fig. 4 where it may be noted that the low frequency jumble remained practically unchanged. The definite noise component occurring at 800 cps arose from the fact that the telephone receiver was designed for resonance at 800 cps. At 1,000 cps may be noted the fundamental note of the tuning fork, and at 2,000, 3,000, and 4,000 cps, respectively, the second, third, and fourth harmonics of the tuning fork note. The "total noise," which consisted principally of the 1,000-cps tone, may be noted to agree rather closely with the physical amplitude of that component.

Obviously the values obtained in these measurements depend not only upon the source of the noise, but also upon the relative positions of the measuring device (the listener) and the noise source, particularly if the latter be a complex piece of machinery. Less evident, but nevertheless true, the amplitude or loudness of a noise depends upon other surrounding conditions such as the sound reflecting characteristics of walls and furnishings, and the manner in which the source of noise (such as a machine) is supported.

"Noisiness" undoubtedly is a characteristic of certain machinery, but its measure in comparable physical units requires carefully detailed specification of the many relevant conditions. In many cases "noisiness" probably is not a fault of any one of the several pieces of machinery involved in a specific case but rather the result of unfortunate chance relationships within the group.

Noise measurements are beginning to be used as a basis for standards of acceptable "quietness" for certain products. Noise measurements provide the principal means used in all efforts to reduce noise; they are effective because:

1. They establish standards by which the effect of changes may be compared, whether the changes be of design of equipment, operating conditions, or even legal restrictions. The ear, used directly, not only is inaccurate, but is terribly misleading unless a *direct* comparison of two noises is to be made.
2. Noise measurements aid in detecting "sounding boards" in complex apparatus. Design changes of these parts or the application of sound absorbent material reduce the noise.
3. Measurements of noise and vibration frequencies are effective because they usually indicate the fundamental source of the sound energy.

Once the mode of production of a noise is understood its reduction may be accomplished relatively easily by reducing the primary driving impulses, by interfering with the transmission of power between its source and the sounding board, by changing the physical characteristics of the sounding board, or by intelligent application of sound absorbing material.

# Transmission Towers Span Railway Tracks

**Transmission lines are carried into the city of Milwaukee, and through adjacent territory, on railway rights-of-way. Special towers have been developed to span the tracks in the more highly congested districts, and studies have been made to indicate which type of tower is the most economical.**

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EXISTING rights-of-way of the interurban railway system are utilized where feasible for the location of transmission towers for the 132-kv and 66-kv lines of the Milwaukee Electric Railway and Light Company and its associated companies. As a result of this practise, 4 different types of tower line construction have been developed. They are as follows:

1. Standard square base towers
2. Two-track bridge type towers
3. Vertical side bridge type towers
4. Four-track bridge type towers

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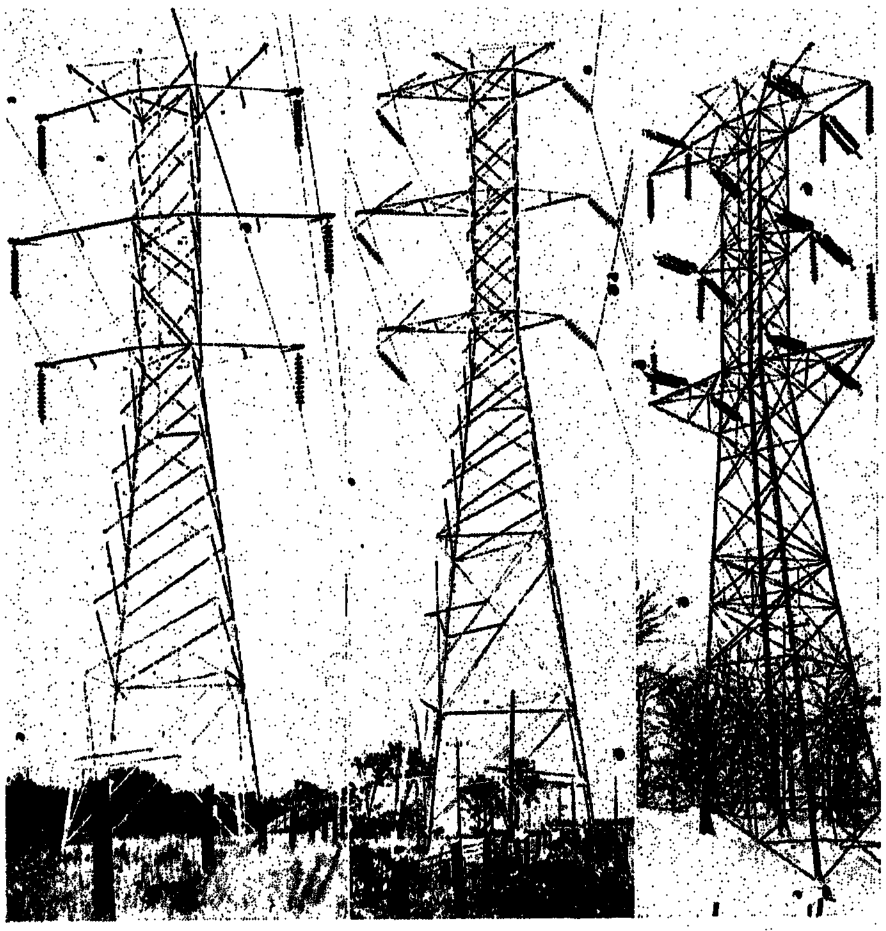
Based upon "The 60-Cycle Primary Transmission System of the Milwaukee Electric Railway & Light Company and Associated Companies in Wisconsin and Upper Michigan" (No. 32M3), presented at the A.I.E.E. Great Lakes District Meeting, Milwaukee, Wis., March 14-16, 1932.

The latter 3 types are used on railway right-of-way where the width available does not allow the use of the standard square base towers. The conductors in these cases are carried in part or entirely over operating tracks. In addition to the high-voltage transmission line conductors, these towers carry the railway catenary construction, supply feeders, and signal circuits. Provision is made also for the installation of from 2 to 4 medium voltage transmission lines.

The primary transmission system, operating at 132 kv or 66 kv, is used to transmit bulk energy from the generating stations to step-down substations, and to interconnect the Milwaukee system with hydroelectric plants in the northern peninsula of Michigan. The capacity of 132-kv transmission lines from 2 of the generating stations, near Milwaukee, to the various substations in the Milwaukee area, has been standardized at 90,000 kva; 300,000-cir mil copper conductors are used together with 90,000-kva transformers. The lines south of Milwaukee are 4/0 copper conductors. The remaining lines are 3/0 and 4/0 ACSR.

## Standard Towers

The square base double circuit tower is used for all lines on right-of-way not occupied jointly with railway, or on railway rights-of-way of sufficient width to allow space for their installation. These towers as well as the various types of bridge towers are designed to support 300,000-cir mil copper conductors strung so that the tension under heavy loading conditions will be 40 per cent of the ultimate. Under the same conditions, the tension in the $^3/_8$-in. Copperweld ground wires will be 39 per cent of the ultimate.



**Figs. 1, 2, and 3. Standard square base towers. Fig. 1 (left) is a suspension tower, Fig. 2 (middle) an angle tower, and Fig. 3 (right) a transposition tower**

The conductor spacing on the suspension tower is 13 ft vertical, with 26 ft and 32 ft horizontal separation, the middle arm being the longest in order to provide a horizontal offset of 3 ft between the conductors of a circuit. The vertical separation on transposition and angle towers has been increased to 16 ft in order to avoid reduction of clearances to ground below those obtained on the suspension tower. On angle towers, the arms are offset an amount equal to the horizontal displacement of the conductor due to the transverse load, thus placing the conductors in an approximately symmetrical position with respect to the head of the tower.

The number of different types of towers used in any line is a question of economics. Four different designs (exclusive of transposition towers) are used at various angles up to a right angle turn. Conductors are supported in suspension up to angles not exceeding 45 deg. Towers at angles of 0 deg to 45 deg are divided into three designs; namely, a standard suspension tower for angles not exceeding 4 deg (Fig. 1); an angle tower for larger angles but not exceeding 20 deg (Fig. 2); and a third type for greater angles up to 45 deg. The range of angles covered by each type will depend upon the number and size of angles in the line in question; but it is believed that the foregoing classification will prove to be economical for average conditions. A fourth design is a dead-end tower, suitable for use at angles greater than 45 deg and not exceeding 90 deg.

Transpositions are made on one tower without a reduction in length of, or crossing of, wires in the adjacent spans. Transposition towers (Fig. 3) are built by installing transposition arms on the body of a 20-deg angle tower, which when used for this purpose will withstand the loads specified for transposition towers.

Since the suspension towers are designed to withstand the unbalanced longitudinal loads due to 2 broken conductors, it has not been necessary to place strain or semi-strain towers at intervals in the line.

## Towers on Railway Right-of-Way

The utilization of private rights-of-way for both railway and transmission has called for marked departure from the square base double-circuit type of tower. Three general types of towers have been designed to best fit the conditions under which they are used.

The 2-track tower (Fig. 4) is a standard double-circuit tower set on a bridge structure spanning the tracks. It has been used on a right-of-way entering the city from the north through a suburban and city district.

The vertical side tower (Fig. 5) is similar to a standard double-circuit tower except that the face toward the track is vertical. The conductors are thereby placed partially over the tracks, requiring less width of right-of-way outside the tracks than if a standard tower were used. At present only one tower has been erected. The other tower and connecting truss will be erected when additional circuits are needed. These towers have been used along the rapid transit line entering the city from the west, where the right-of-way was of sufficient width to accommodate them.

The 4-track tower (Fig. 6) has been used on the same line but closer to the city where real estate values preclude the purchase of more right-of-way than is essential for railway purposes. This design centers the conductors over the rails and as close to each other as is practicable. Each set of conductors in an approximately vertical plane comprises one circuit so that they can be worked on while the others are operating. Access to the middle circuit is obtained by walking on a grating placed on the bottom of each truss. The truss is 5 ft in height. A modification of the 4-track tower is shown in Fig. 7. It was used where the railway grade was high and not of sufficient width to accommodate 4 tracks, at a point where the tracks cross the Menominee River.

All towers over tracks have been designed to accommodate railway trolley and feeders, and 26.4-kv lines in addition to the 132-kv lines.

Of the different types of towers utilized in extending the 132-kv system on or along private railway rights-of-way, it is obvious that the structures bridging the tracks cost more than the vertical side towers. The type of towers to be installed is a question of economics based upon real estate values at the particular location. In many of the outlying suburban areas there was the alternative of using the 2-track bridge type tower and utilizing, for the most part, the same right-of-way; or of purchasing additional right-of-way to permit the use of standard towers. The results of a study of this situation showed that the bridge tower is more economical if the cost of additional right-of-way for transmission only exceeds $1,200 per acre. If the cost is less than this amount, it is economical to purchase additional land adjacent to the existing railway right-of-way in order to accommodate standard towers.

## TOWER DESIGN

The design of the standard towers is for the most part along conventional lines, differing only in some details. One such departure from the usual practise is the use of the "drip plate," a 16-in. octagonal steel plate placed above the point of insulator support. Operating experience shows that under certain favorable conditions, water which collects on the crossarm brace will flow down the brace to the end of the crossarm and drip over the insulators, forming icicles. These icicles shunt the porcelain and have sufficient conductivity to permit a flow of current which will operate the ground relays. The function of the drip plate is to act as an umbrella in diverting the drip water away from the insulators.

The system is within the area defined by both the state and the national codes as a heavy loading district. Records show that wind has not exceeded 40 miles per hr (4 lb per sq ft pressure) while there was ice on wires, and the ice formation has not been as heavy as 1/2 in. ice radial thickness. However, it is known that in other parts of the state, ice has formed more than one inch in thickness. In order to guard against service interruption, a load equal to that imposed by one inch ice and 8-lb wind pressure at 0 deg fahr has been specified. This is approximately double the loading specified by the codes. All towers are designed to withstand transverse and vertical loads resulting from these conditions plus the unbalanced load due to any 2 conductors being broken. The unit stresses in the material are such that the elastic limit will not be exceeded if the loads specified are increased 10 per cent on standard towers and 25 per cent on towers spanning tracks.

The steel grillage type of anchor requiring no concrete, has been generally used for suspension and the lighter angle towers, while concrete has been used for the heavier towers and all towers over tracks. The Malone anchor has been utilized to some extent for suspension towers and found satisfactory where the soil conditions are suitable for its use.

The normal span length of the lines over 4 tracks is 510 ft. This is limited by the length of the maximum railway catenary span, which, on account of the track alinement, was found to be 255 ft. Other supports intermediate between the transmission towers carry the railway equipment only, resulting in a transmission span double that of the catenary span. The towers over 2 tracks are spaced at 600 ft. This also is double the railway catenary span, which on account of larger radii curves, is 300 ft. The double circuit square base towers are spaced at 650 ft maximum. This has been found to be an economical span length for the average conditions under which the various lines are constructed, taking into consideration width of right-of-way, land values, and clearances from other structures.

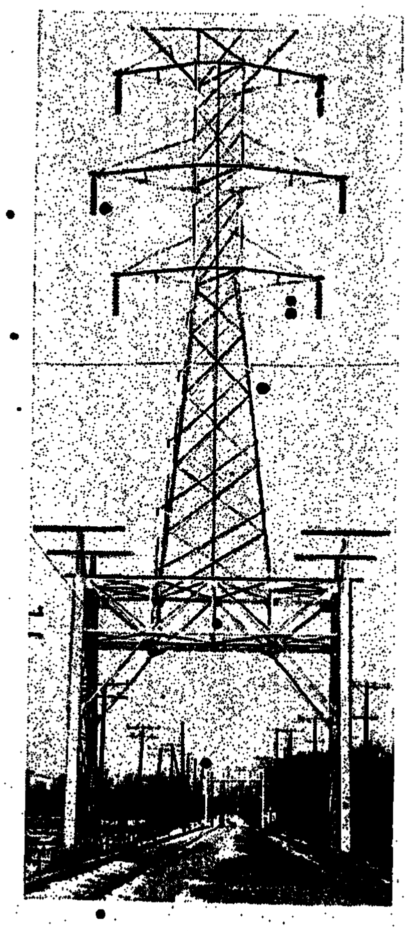


**Fig. 4. (Left) A typical 2-track bridge tower**

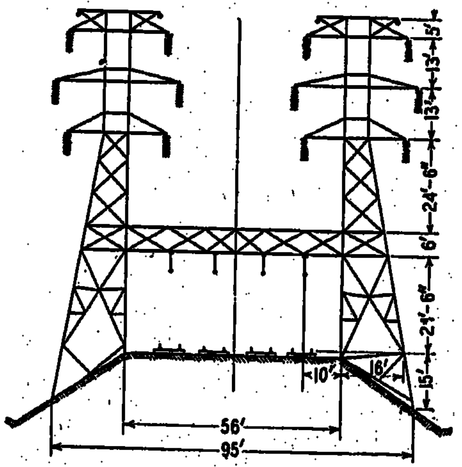


**Fig. 5. (Below) Elevation of a typical vertical side bridge tower with truss**

## GROUND WIRES

Lines constructed previous to 1925 were not equipped with ground wires, but provision was made for one wire at the tip of the tower approximately $8^1/_2$ ft above the top conductors. Operating experience available at that time on this and other utility systems, indicated that the presence of a ground wire did substantially reduce the number of interruptions due to lightning. Ground wires were then installed on all existing lines and since that time have been included in the initial construction of all lines.

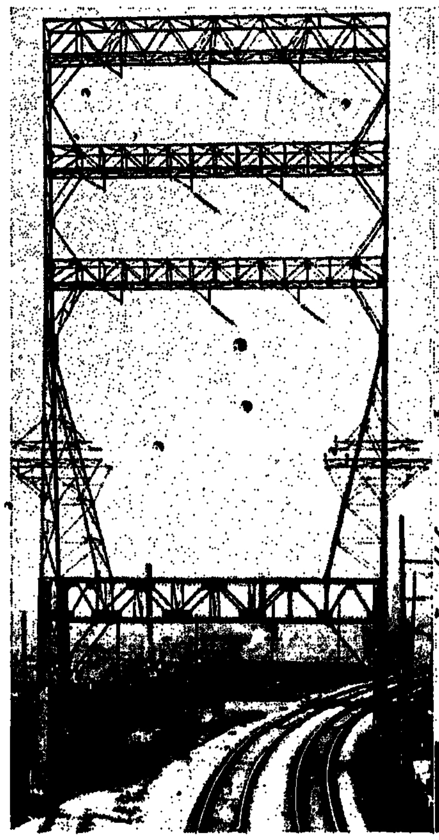


**Fig. 6. (Left) A 4-track, 3-circuit bridge tower**

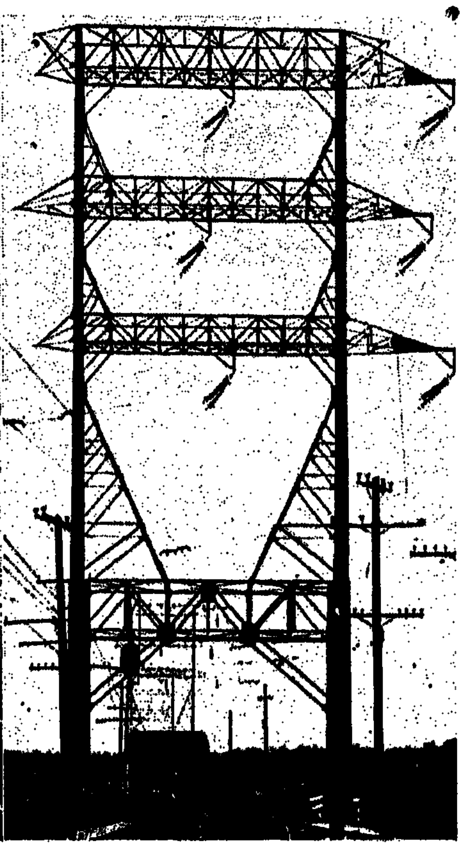


**Fig. 7. (Right) A 2-track, 3-circuit bridge tower**

Ground wires are $^3/_8$-in. Copperweld supported by a suspension clamp on suspension towers and by dead-end clamps at angles and dead-ends. The suspension clamp provides a flexible support, minimizing, if not eliminating, the bending of the wire at its support. This method of support is used as an added precaution against mechanical failure of the ground wire.

The line placed in operation early in 1931 is equipped with 2 ground wires, each of which is offset 3 ft horizontally and separated 12 ft vertically from the top conductor. The sag of the ground wire is less than that of the conductor, making an average vertical separation of approximately 16 ft.

## INSULATION AND PROTECTIVE DEVICES

The older 132-kv lines are equipped with 10 $4^3/_4$-in. spaced suspension insulator units with 15-in. horns at the conductor end. The horns are effective in protecting the conductor against burning, and the lower insulators against damage by power arcs. This insulator string has an impact flashover of approximately 700 kv. Flashovers and the power arc following have often damaged the porcelain of the upper insulators of the string, but there has been only one case, and that during a severe rain storm, when service could not be restored without replacing insulators.

Flux controls, devices having the general appearance of horns, but having insulators on the tips, are used on 32 miles of line. Laboratory tests show that these devices will protect the insulators against discharges of from 50,000 to 70,000 cycles per sec. Although it has been shown that such frequencies can be present on the line, it has not been shown that they occur frequently enough to warrant protecting against them. This is borne out by the operating record of this line, which, from the time of the installation of the flux controls in 1926 to date, is substantially the same as the other circuit carried on the same towers, but equipped with 15-in. horns.

The most recent line to be placed in operation is equipped with V.S. arcing horns on a suspension insulator string consisting of 10 $5^3/_4$-in. units. The impact flashover of this assembly is 820 kv The purpose of the horns is to protect the porcelain against damage by confining the arc to the horn tips, thus permitting restoration of service immediately following the oil circuit breaker operation. Dead-end insulation consists of 2 12-unit strings in parallel and equipped with V.S. horns on which the impact flashover is 980 kv.

At the Lakeside generating station, near Milwaukee, each outgoing 132-kv line is fed through its own transformer bank, which is protected by a lightning arrester against surges originating on the line. At substations the transformers are protected by a lightning arrester connected to the bus. Ultimate plans provide for an arrester on each bus section to which transformers are connected.

At all generating stations and substations connected to lines equipped with V.S. horns, the horn-gaps nearest the station are set to protect the station apparatus as well as the line. At switching stations where there is no equipment with bushings connected to the 132-kv line, no reduction need be made in the length of gap used on the suspension tower. Laboratory tests show that this gap of approximately 47 in. will always flash over before the bus insulators or the 4-unit pillar insulator on the air-break switches. At stations where there are bushings to be protected, the gap has been reduced to $36^1/_2$ in., resulting in a flashover value just below that of the bushings. These protective horn-gaps are placed on the dead-end line insulators, except where they would be in close proximity to an air-break switch. In this case they are placed on the tower one span away.

The 66-kv system of the Wisconsin-Michigan Power Company in upper Michigan consists of both steel tower and wood pole construction. The steel towers are of the conventional double circuit type similar to those on the 132-kv system, except that neither the loads nor clearances are as great. Where a single circuit line of small conductors meets the requirements, the wood poles are the more economical. Another advantage over steel towers is that they can be set along highways and streets, where they are available for distribution circuits.

# Brass Tacks in Economics

**Less investment money and more buying money is needed today; one proposal to increase buying power without harming business is by the drastic taxation of great incomes. This is the thirteenth article in the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"**

By
DAVID CUSHMAN COYLE Consulting engineer, New York, N. Y.

SCIENCE never is finished, but the engineer cannot wait. While research is exploring the theory of stresses, the engineer must take what facts he can get, use the means available, and drive the job forward. It is the same with economic fact-finding. Look at the bituminous coal industry: Facts are basic, but not dynamic. Making the economic machine run is a problem in simplification, decision, and determined action. What is wanted? Where is the sticking point? What power is available? What will it cost?

There are two incompatible economic projects. One is that of bringing the great accumulations of capital through the storm with the least possible loss. The other is involved in this question: If we can easily make all the things any reasonable person wants, and plenty for everybody, why not do it? Radicals and conservatives will favor the first project, the former because they know it leads to revolution, the latter because they do not know that the attempt is hopeless. The second project is a constructive, common-sense idea, and therefore peculiarly suited to the engineering mind. Following is an outline of this second project.

## TOO MUCH INVESTMENT MONEY POISONS BUSINESS

The sticking point is in the construction and machinery industries, the production of "capital goods." Too much money goes into factories and office buildings and new coal mines; then overhead consumes all the profits, and paralysis sets in. The system as a whole is as inefficient as possible. First we build factories that cannot run and floor space that nobody will occupy; then we spend several years doing nothing of any consequence. Our work is stultified by the irrational behavior of finance.

Investment money flows into industry and trade when prospects look good, and causes overexpansion; then it flows out and causes deflation. It causes instability and profits thereby, and for that reason it is poisonous to business. The Federal Reserve is supposed to counteract this action of private finance; but it has not been strong enough. Investment money flows into overequipment, and when industry has been well poisoned it vanishes in bankruptcies, wrecking business, but not removing the excess equipment. There is too much investment money. The opportunity to invest money without poisoning business is limited. Moreover there is too little buying money. The income of the country must be directed more to useful consumption and less to economic poison.

What power is capable of turning the flow of money into useful channels and releasing us from the vicious circle of wasted work and unemployment? History indicates that those who suffer most are likely to be most interested in applying a remedy. Working drawings must be intelligible to workmen; any plan that is to come down out of Utopia and take on reality must sacrifice comprehensiveness to simplicity. The most obvious device is communism, but it hardly seems suited to the American temperament. A more practical method of steering money into consumption would be one that would be acceptable to the workers and the middle class, because together they have the necessary power to put it into action. Heavy taxes on the great individual incomes with rebates for approved contributions, would effectively reduce overbuilding and turn the money into public and semi-public construction; this would increase buying power without harming business.

## DRASTIC TAXATION OF GREAT INCOMES WILL STABILIZE BUSINESS

What will it cost to stabilize business growth by drastic taxation of great incomes? First, it will cost giving up forever the hope of becoming a multimillionaire. Success, beyond a certain point, will have to be measured in honors, fame, offices, anything else but vast sums of money. The money is needed to lubricate business via the buying market. Second, it will mean slowing the maximum rate of construction of new plant. Our present *average* rate is slow because we stop periodically. This could be avoided if we would tax consumption and use the money to tear down old plant; but although it would cure overequipment it would be inefficient because too much energy would go into premature replacement. There is a finite optimum rate of replacement, which with our tremendous productive power we could overpass easily. By diverting capital funds into the destruction of old plant as well as to building cultural equipment, we could get the maximum of useful products out of the system in the long run.

The third cost of the limitation of capital accumulation will be that it will tend to decentralize initiative. The incentive for centralized control will be reduced and that for setting up small concerns

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This article has been checked by Virgil Jordan, economist, McGraw-Hill Publishing Company, Inc., New York, N. Y.

will be increased. That may seem horrifying at first; and yet, could any arrangement be more inefficient than the present one? In any event it is the price of freedom, and of the overall efficiency which we lack now.

No system with the high productive power of our own can be made to run unless the construction of equipment is artificially kept in check. If we go in for centralization, we shall be forced to adopt socialism as a means of limiting investment. If we limit the volume of investment money by taxation, we can avoid the abolition of individual initiative. The latter method crudely but effectively will do the job; it is simple enough to be comprehended by the voters who have the power to put it into action; and the cost is less than the cost of drifting on into collapse and revolution. It will be well for engineers to consider these points, devise a still simpler and more effective plan if possible, and then push for action.

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**Editor's Note:** Pursuant to the invitation of the Engineering Foundation, the editors will be happy to receive comments, criticisms, or discussions pertaining to this or other articles published in this series.

# Welding Steel Structures

WELDING with gases and electricity are relatively new processes but have a background of more than a decade of scientific research. In recent years such welding has been adapted to buildings and bridges. Noise elimination, economies, and ease of application are a few reasons for adoption by the structural steel industry.

Welding came to the attention of engineers during the World War as an aid in shipbuilding. Prior to this time, it had been used with varied success in repair work, particularly on the railroads. Good welds could be produced under certain conditions, whereas poor welds resulted under others. Welding experts were unable to give satisfactory reasons for this, but investigations started during the war were continued. With the organization of the American Welding Society and its research department, the American Bureau of Welding, this research work was expanded.

Leading structural engineers a few years ago began to study the application of welding to the fabrication of steel structures. Investigators in this country and in Australia undertook tests. A few important structures were fabricated by welding, including some gas holders in Australia, some small ships here and in Europe, and a few small buildings in this country and in England.

An outstanding contribution to the extension of welding in structural work was the 5-yr program of the Structural Steel Welding Committee. Its scope and thoroughness commanded the attention of architects and engineers. It involved the fabrication and testing of several thousand specimens welded by 61 welders at 39 shops and tested at 24 laboratories including college and commercial institutions, and the U.S. Bureau of Standards. This research disclosed no harmful effect on the base metal due to welding.

Since tests on 2,495 specimens indicated that joints commercially welded by qualified welders may be expected to possess strengths within 12 per cent of general average results, engineers and architects may feel secure in expecting in their completed structures, the strengths required.

A few random instances will bring out these advantages. A new hotel building had to be erected at Hot Springs, Va., between 2 existing structures. It was necessary to avoid the noise of riveting. This structure was 12 stories high, and was the first so-called tier building of this size to be welded. A 5-story heavy duty warehouse was constructed by American Bridge Company for Westinghouse Electric & Manufacturing Company. The continuity of beams and girders which was provided resulted in a 12 per cent saving in steel.

A 10-story office building in Cleveland, housing physicians and dentists, was enlarged without disturbing the occupants. The gas torch and the electric arc made this possible, thus saving the owners thousands of dollars in rentals. It was necessary to make only small openings in the old walls uncovering the face of the old steel where the connections were to be made. Much wrecking was eliminated.

Steel building frames may be welded with either the gas torch or the arc. The largest structure thus far welded with a gas torch is a research laboratory 75 ft wide, 260 ft long and $42^1/_2$ ft high, at Niagara Falls. The tallest arc welded structure is a 19-story office building for the Dallas (Tex.) Light and Power Company. The heaviest welded truss to date weighs 60 tons; it has a span of 96 ft and a height of 18 ft. In the United States several hundred steel structures have been welded either totally or partially. No failure has occurred in any welded joint.

Aside from the economic value of noise elimination, in many locations, the saving lies principally in the use of less steel in trusses or plate girders. In the multi-story building frames consisting of welded beams and columns, the decrease in weight of steel is small unless the beams be made continuous; but thus far the cost of additional welding has offset the saving in steel. In several buildings, some of them 14 stories in height, the cost to the owners when the shop work was riveted and field work welded, was the same as if both shop and field connections had been riveted. This equality reveals a decided advance in a short time. In ordinary roof trusses savings in weight of steel are pos-

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From *Research Narratives*, April 15, 1932, published by the Engineering Foundation, 29 West 39th St., New York, N. Y. Based upon information contributed by W. Spraragen, Secy., American Bureau of Welding, New York, N. Y.

sible amounting to as much as 36 per cent. Similar savings are obtained in plate girder construction.

The American Institute of Steel Construction is sponsoring the battledeck floor for buildings. It consists of thin flat steel plates two feet or more wide resting upon the upper flanges of parallel I-beams. As the adjacent edges of two plates run along each I-beam and a narrow space is left between them, these edges are welded together and at the same time to the top of the I-beam, thus producing a composite beam. Automatic machines are available for the welding.

More than 125 municipalities have adopted welding in their building codes. With accurate design data, control of products is made sure through the employment of qualified welders and inspectors, and designs adapted to welding.

Welding has been helpful in steel buildings to resist earthquake and wind, which in some instances would require unusually elaborate designs if riveted. An example is the new headquarters of the Southern California Edison Company, Ltd., in Los Angeles.

All-welded steel frame houses are possibilities of the future. Several such experimental houses have been erected at a cost which compares favorably with wooden structures. General adoption would provide an outlet for more than a million tons of steel annually.

# Electrochemistry and Hoover Dam

**Two mining authorities here outline some of the possibilities for electrochemical developments at or near Hoover Dam in connection with the expected availability of large quantities of cheap power and water and the known mineral deposits of the West.*—Editors.**

WITHIN 6 years the construction of Hoover Dam and the power plants probably will have reached the operating stage and this vast new source of power then will be available for industry.

The average annual flow of the Colorado River is calculated at approximately 24,000 cfs, and if this average flow can be maintained the year round at the full head provided by the 580-ft dam about 1,000,000 hp will be generated. Government engineers, taking into consideration the probable range in flow and head, have set the figure for power contracts at 660,000 firm horsepower, which can be assured at all times of the year. During the months of heavy run off the power plants should be able to generate their full 1,000,000 hp; hence there will be 340,000 excess or secondary horsepower. The cost of firm power at the switchboard will be close to 2.15 mills per kwhr, equal to $14.05 per hp-yr, and the cost of the secondary or off peak power will be close to 0.8 mill per kwhr, or $5.22 per hp-yr. At no place in the country can such cheap power be obtained today.

The electrochemical industry is in a state of flux because the cost of power from its old sources has increased so much (to $30 per hp-yr at Niagara) that the industries have gone to Canada and Norway and built new plants. Dr. C. G. Fink, secretary of the American Electrochemical Society and an accepted authority on matters concerning the electrochemical industry, made the following statement at the hearing on disposal of Boulder Dam power before Secretary Wilbur in Washington, D. C., in November 1929: "It is my opinion and conviction that the American electrochemical industry will be ready to absorb all of the power developed by the Boulder Canyon project as soon as it is available." Doctor Fink also stated that "transmission costs are higher than transportation costs for raw material or finished product."

The power situation as briefly outlined, coupled with the fact that the Hoover Dam area is one of the richest in the world in raw materials used by the electrochemical industry, insures the creation of an immense electrochemical and electrometallurgical industrial center in southern Nevada. The following is a brief résumé of the more important industries that will be created to use this cheap power, and a brief description of the metallic and non-metallic resources in southern Nevada and contiguous territory.

## ELECTRIC FURNACE INDUSTRIES

Numerous electric furnace industries are possible. Calcium carbide can be manufactured, for limestone of high purity exists in unlimited quantity near the dam. Although coke will have to be brought in from Utah, the low power rate at the dam will more than offset this.

Cheap power may make possible the calcination of this pure limestone in electric furnaces, obtaining quicklime as one product, carbon dioxide gas as another. Dolomite also occurs in unlimited beds near at hand, to be calcined for various uses, as done there now with oil furnaces. The carbon dioxide gas would fit into the picture to convert synthetic ammonia to carbonate, which in turn may be elutriated with ground gypsum to form ammonium sulfate fertilizer, and produce hydrated lime as a by-product. By this process millions of tons of ammonium sulfate are manufactured annually in Germany.

Ferro-alloys of vanadium, molybdenum, manganese and silicon can be manufactured from ore supplies all within 40 miles of the dam. Tungsten will come from central Nevada. Pig iron can be brought from Utah, or iron for such alloys can be produced from the large deposits in southern California and Nevada. In San Bernardino County, California, is a splendid deposit of at least 5,000,000 tons of magnetite, only 150 miles by rail from the dam site. In northeastern Riverside County, California, is the great Iron Chief deposit, conservatively estimated at from 20 to 75 million tons, distant only 200 miles from the dam. Other large deposits also exist in the West.

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* Abstracted from an article "Possibility of Electrochemical Industries at Hoover Dam" written by Jay A. Carpenter—professor of mining, University of Nevada—and Alfred Merritt Smith—mining engineer, Nevada State Bureau of Mines—and published by the American Institute of Mining and Metallurgical Engineers, Inc., in "Mining and Metallurgy" for August 1932.

The sponge-iron process has possibilities wherein Utah would be called on to supply cheap slack coal for the necessary reduction before the electric smelting of the sponge iron. The pioneer plant at Heroult, Calif., several years ago proved electric iron smelting to be practicable, and success dependent on costs alone. Here is a wide new field in the direct production of steel and steel alloys from the ore.

## NITRATES AND AMMONIA

Very cheap power and an absence of coal suggests the adoption of some method of nitrogen fixation using only air, water, and power, such as the Birkeland and Eyde and Doctor Schonherr's methods in use in Norway by plants consuming 360,000 hp. The nitric acid so produced has high market value, and nitrate nitrogen is desirable for explosives manufacture, a large industry on the Pacific Coast. High-power explosives for military protection can be manufactured near the dam, a point remote from air attack and near the great new United States munitions storage depot at Hawthorne, Nev.

Although the Haber-Bosch ammonia process now is used to produce most of the world's synthetic ammonia, nearly all of the plants consume coke and coal both for power and to produce the gases used. However, in the last few years synthetic ammonia made from hydrogen derived from the electrolysis of water and nitrogen obtained from the air, has become of importance where cheap power is available.

Tadanac, near Trail, B. C., offers an outstanding example of water electrolysis on a commercial scale. Hydrogen from the electrolytic disassociation of water, and nitrogen from a liquid air unit are used in producing synthetic ammonia by direct combination under pressure with a catalyst. This, too, although the plant is not remote from good sources of Washington coke and coal. Tadanac long has been a great center for electrolytic lead refining, and it was there that selective flotation of complex lead-zinc ores made a great advance. The $10,000,000 fertilizer plant now under construction there consists of an electrolytic hydrogen unit to produce 3,000,000 cu ft of hydrogen per day; a liquid-air unit for the production of nitrogen; and a synthetic ammonia unit to produce 47 tons of anhydrous ammonia per day. Thus have low-priced power and basic materials built up this great group of industries in a location more remote from markets and having a climate much inferior to that of the Hoover Dam for living, labor, and operating conditions.

## ELECTROLYSIS

Electrolysis of salt produces sodium hydrate and chlorine, the base and acid for a wide range of chemical uses. Four large salt deposits in Virgin Valley, 50 miles from Hoover Dam, contain at least 25,000,000 tons of rock salt. Rock salt and also calcium chloride occur in inexhaustible quantities at Bristol Dry Lake, San Bernardino County, 150 miles from Hoover Dam. Great quantities of sodium hydrate might find use in the refining of California petroleum. Hydrochloric acid made from the chlorine may possibly be used in the manufacture of pure iron by electrolysis of a solution of ore in acid. Cheap power would be the key to this method, with the natural resources ready at hand.

## THE METALS

*Zinc.* The U.S. Bureau of Mines reports that Arizona, Nevada, New Mexico, Oregon, Washington, and Utah mines produced 93,018 tons of recoverable zinc in 1930. For the same year Colorado and Montana produced 155,718 tons. Most of the ore was reduced in electrolytic plants in Montana and Idaho and represents 26.5 per cent of the total United States production. During the years 1930 to 1932 the mines of Pioche, Nevada, enormously increased their ore reserves; they now have about 4,000,000 tons of ore blocked out, with the possibility of much more lead-zinc-manganese ore to be developed soon. To provide for this increased production, particularly in Nevada, large concentrating and calcining plants may be built at Pioche, about 150 miles north of the dam. The calcine could be shipped to the dam for electrolytic refining. About 16 per cent of all the sulfuric acid used in the United States is produced by zinc-roasting plants. Probably all of the Pioche acid would be absorbed by industries at the dam, chief of which should be the refining of blister copper.

*Copper.* In the West, there are electrolytic copper refineries at Great Falls, Mont.; Tacoma, Wash.; and a new plant at El Paso, Tex. Doctor Fink states that these will not take care of western copper output, but will leave all of Nevada (54,601 tons in 1930) and half of Utah and Arizona (about 500,000 tons in all) to be sent east for refining. It would appear that for more economical operation a plant should be located at Hoover Dam, in the center of the heaviest producing districts, and a point on the direct route to the Coast.

*Aluminum.* Doctor Fink points out that all aluminum used in the western half of the United States is subject to an expensive cross-haul, bauxite from Arkansas going east for reduction and then west again as metal. Six million pounds per year is shipped to the Orient, in addition to large amounts used in the western states. A deposit of pure alunite is being developed at Sulphur, Humboldt County, Nev. Marysvale, Utah, also is a source of this aluminum-potash mineral. Other localities in Nevada and Utah may be able to supply some of this ore. A commercial process for recovering both aluminum and potash from alunite should not be difficult to work out, given cheap power and abundant water.

*Manganese.* Various deposits of manganese ore occur in the western states. In Nevada, at Golconda and Ely, small tonnages of high-grade ore are produced, and at both Las Vegas and Pioche are large bedded deposits. The probable tonnage of manganese ore, associated with zinc and lead in the Pioche district, now amounts to about 4,000,000 tons. Possibly 2 or 3 times as much will eventually be developed. The Combined Metals Company at Pioche is perfecting a commercial process for the separation of manganese, which can probably be carried out most advantageously at the dam site, where, in any event, the next steps of making ferromanganese or using the ore in chemical industries would be carried out. Only 10 miles northwest of the Hoover Dam is another large bedded deposit of manganese ore, which geologists Hewett and Webber of the U.S. Geological Survey estimate to contain at least 500,000 and possibly 1,000,000 tons. As manganese ore imports in 1930 were 585,568 long tons, and domestic production of all classes, including 708,000 tons of manganiferous iron ore was only 845,000 tons, the need of cheap domestic manganese is seen. Ferromanganese can be made cheaply in electric furnaces at the dam site, and thus be ready for market at exceedingly low cost for the ores.

*Tungsten.* Nevada and California together produce most of the tungsten consumed in the United States. The largest western production is made at Mill City, Nev., and Atolia, Calif., which together produce about 80 per cent of all that used in the United States. (In 1930, 702 tons of 70 per cent $WO_3$ was produced.) A portion of Nevada's production of 64 per cent of the total, which is now shipped to Niagara Falls for reduction, could be converted to ferro-tungsten at the dam, for western and Oriental consumption, at a great saving.

*Other Minerals and Metals.* Within commercially practical distances of Hoover Dam lie tremendous deposits of other minerals and metals including alum, borax, brucite, gypsum, clays (bentonite, kaolin, diatomite), feldspar, fluorspar, limestone, magnesite, molybdenum, silica (good quality), sodium sulfate, sulfur, and vanadium.

### ECONOMIES POSSIBLE

To the materials already mentioned must be added platinum, gold, silver, mercury, cobalt, and bismuth, all of which are found in Nevada and California near the Hoover Dam site. Great economies to the mining industry seem possible through the establishment of reduction plants and refineries at this source of electric energy.

# Distribution System Lightning Protection; Operating Experiences With Lightning Arresters

**Operating experience demonstrates that lightning arresters provide sufficient protection to justify their installation on electric power distribution systems even where low arrester ground resistance cannot be obtained. Limited experience with the interconnected lightning arrester ground and grounded secondary neutral confirms the results of laboratory and field tests covered in a group of articles published on p. 633–47 of the September issue of ELECTRICAL ENGINEERING.**

PROTECTION of electric power distribution systems from disturbances due to lightning is a problem of major importance, since many interruptions to customers are due directly to troubles from that source. Statistical studies show that lightning arresters provide sufficient protection on distribution systems to justify their installation economically. Results of 3 such studies on 3 typical large power systems are covered in the 3 articles immediately following this introduction.

The first article, by Roper, treats of a cooperative investigation on the system of the Commonwealth Edison Company, Chicago, conducted by several lightning arrester manufacturers in cooperation with the power company. The second, by Haines and Corney, gives the results of a study on the system of the Edison Electric Illuminating Company, Boston, in a region where high ground resistances prevail. The third article, by Dambly, Ekvall, and Phelps, covers a study on the different types of lines that make up the distribution system of the Philadelphia Electric Company, and includes field tests with the interconnected primary arrester ground and grounded secondary neutral.

From the results of these and similar studies, quite definite rules now can be laid down for reducing the effects of lightning disturbances on distribution circuits. As determined in previous investigations, a marked improvement in protection is effected by increasing the arrester density, that is, the number installed per square mile of area protected. The age and size of transformers also appear to have some effect, the smaller transformers being more susceptible to lightning troubles as are those of older design. Low resistance for arrester grounds appears to be of great importance, although considerable protection can be obtained even with ground resistances as high as 1,000 ohms. There is a difference of opinion as to whether grounded systems are less susceptible to lightning disturbances than are ungrounded systems. A difference of opinion also exists in regard to the shielding effect of tall buildings, trees, and other structures.

# I—Experience on a Typical Urban System

By
**D. W. ROPER**
FELLOW A.I.E.E.

Commonwealth Edison Company, Chicago, Ill.

By taking advantage of knowledge gained from a 20-yr statistical research investigation of lightning protection for distribution circuits (Fig. 1), it appears possible to reduce the number of transformer troubles caused by lightning in Chicago to less than one case of trouble per year per thousand transformers in service. This article presents some of the later results of that 20-yr study.

Following the development of the cathode ray oscillograph in form suitable for tests on lightning arresters, it was noted that test results, as then made and interpreted, placed the several types of arresters in a different order of merit from the order indicated by field investigations. This resulted in a conference with the lightning arrester manufacturers on the subject in January 1927, at which time plans were formulated for determining the causes of these discrepancies. Practically all of the additional information on the subject recorded in this article has resulted from the intensive study begun during this conference. During the succeeding years 6 more conferences were held; as a result, practically all of the differences which appeared in the first conference have been reconciled. As the manufacturers of lightning arresters now are able to make tests with the lightning generator and to interpret the results by means of the cathode ray oscillograph, so that by such studies the relative merits of various types of arresters can be closely determined, the detailed statistical investigations in Chicago no longer are warranted and hence have been practically discontinued.

## Chicago Distribution System

The system of distribution in Chicago is a 4-wire 3-phase 2,300/4,000-volt system with the neutral grounded at the substations. All of the 606 circuits leave the substations underground; the feeders and about $^1/_5$ of the mains are underground. On August 1, 1931, there were 33,093 transformers connected to the overhead mains; in addition 1,593 were installed in manholes or vaults and connected directly to underground primary mains. Over 800,000 customers are served by this distribution system, which covers about 120 of the 210 square miles within the Chicago city limits.

All line transformers are single-phase, with 2,080-volt primaries and 115/230-volt secondaries. Lighting transformers are connected between a phase wire and neutral; the secondary neutral wire is well grounded along the secondary mains and on the customers' premises. Transformer cases are not grounded. Large power installations consist of 3 transformers connected in $Y$ on the primary and in $\Delta$ on the secondary; the common point of the primary connections is not connected to the primary neutral, and the middle point of one transformer secondary is grounded. Smaller power installations consist of 2 transformers each connected between one phase wire and primary neutral with the secondaries connected in open $\Delta$. Secondary lighting mains generally are only one block long, but about $^4/_5$ of these secondary mains have their neutrals connected with the neutrals of mains in adjacent blocks.

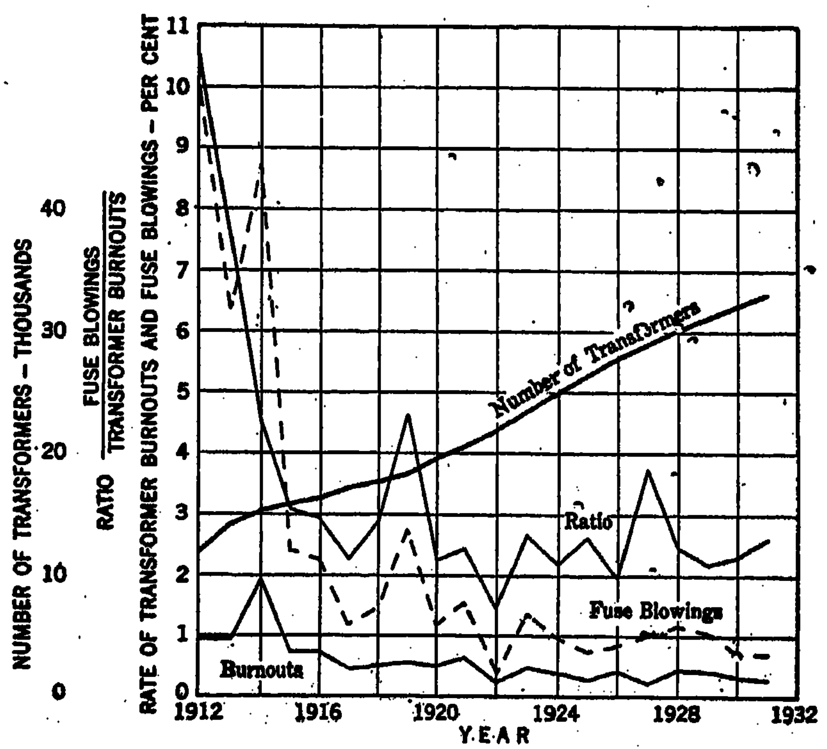

**Fig. 1: Records of transformers and lightning troubles for a 20-yr period**

Even though the number of transformers doubled between 1915 and 1931, the actual number of transformer burnouts and fuse blowings remained fairly constant at 105 and 275 per year, respectively

One 3-kv and one 300-volt arrester (Fig. 2) are installed on the same pole with each lighting transformer; similar installations are made at the banks of 2 or 3 power transformers with the further limitation that the maximum number of phase arresters on

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Based upon "Studies in Lightning Protection on 4,000-Volt Circuits—III" (No. 32-19) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932.

### Table I—Results of Examination of Transformers Burned Out in Chicago by Lightning During 1927–30, Inclusive

| Apparent Lightning Entrance | No Transformers Examined | Per Cent |
|---|---|---|
| Primary only: | | |
| Phase wire | 133 | 28.0 |
| Neutral wire | 32 | 6.8 |
| Phase and neutral wire | 42 | 8.9 |
| Total, Primary only | 207 | 43.7 |
| Secondary only | 100 | 21.1 |
| Secondary and primary | 105 | 22.2 |
| Doubtful | 38 | 8.0 |
| Indeterminate | 24 | 5.0 |
| Total | 474 | 100.0 |

Note: In these investigations a transformer is considered to be burned out when it cannot be restored to service without removing it from the pole. About 40 per cent of the transformers were repaired without replacing the coils.

transformers in any one block is 3. Similar installations are made on all cable poles. No lightning arresters or similar devices are installed in any of the substations, on the secondary mains for light or power, or on transformers connected to underground mains.

At present 15 types of 3-kv arresters are in use on the system, which, for the purpose of this investigation, was divided into 162 areas with only one type of arrester in any area. The several areas for each type are scattered throughout the city. For grounding the arresters 10-ft ground rods are used except in sandy regions, where 15-ft rods are used; in the few rock areas special methods are employed.

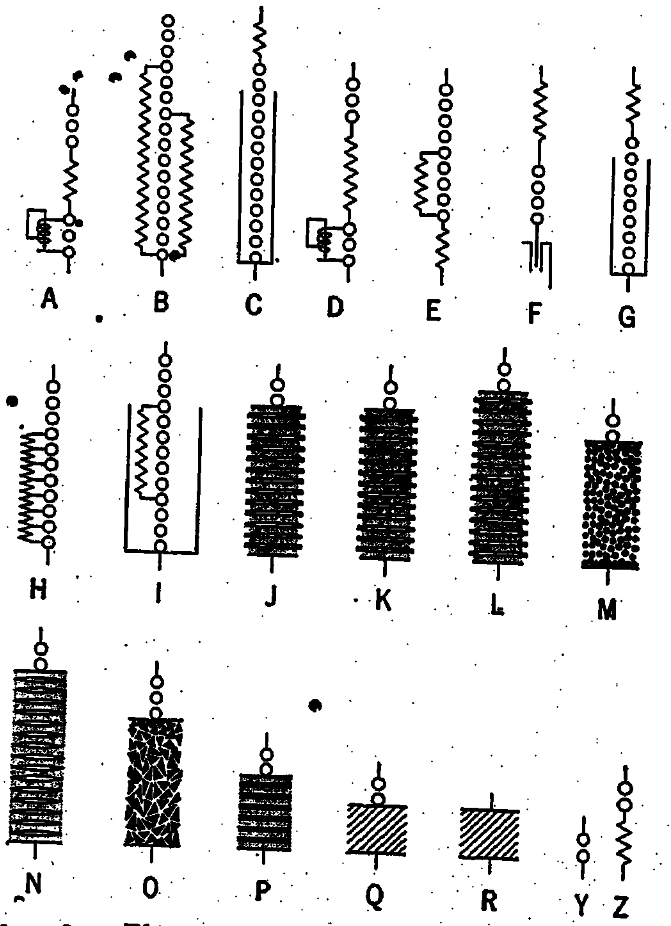

**Fig. 2. Electrical diagrams of arresters used**

Gaps and resistors are shown by conventional symbols, lower end of diagram is ground side. Types A to R are 3-kv arresters. Types Y and Z are 300-volt arresters. In types C and G narrow grounded bands of metal are carried up the sides, while in type I, a grounded metallic cylinder surrounds the lower $^3/_4$ of the arrester. Arresters J to R are valve types. Arresters are arranged in the order in which they were installed on the system

## EXAMINATION OF BURNED OUT TRANSFORMERS

Records of the examination of 474 transformers burned out by lightning (Table I) indicate that burnouts starting in the secondary winding (Fig. 3) were nearly half as numerous as those starting on the primary. Lightning potentials on the secondary service wires, however, have caused but little trouble on customers' premises. Information obtained in the examination of the transformers confirms the suggestion in the 1914 paper of the author that careful attention should be given to clearances of leads inside and outside the transformer case. (See "Experiences With Line Transformers," A.I.E.E. TRANS., v. 33, 1914, p. 685.)

Evidences of direct strokes, as indicated by shattering of poles or cross-arms, were found on only about 15 poles per yr., or one in 9,000. Only about 5 per cent of the transformer failures appear to be caused by direct strokes. Apparently there are practically no traveling waves on the distribution system. This assumption is based upon the fact that records for transformers at the open ends of primary wires show that the percentage of trouble is about 20 per cent below the rate for other transformers. Were traveling waves existent on the system, there would be an increased percentage of trouble due to piling up of potential at these points.

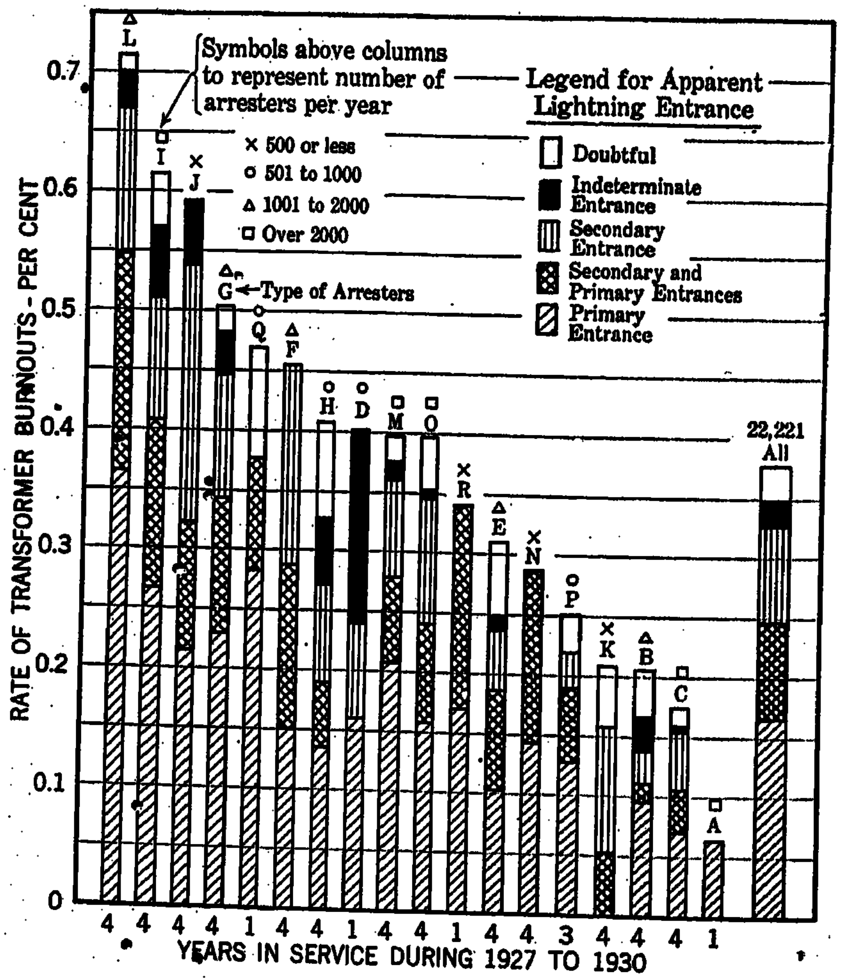

**Fig. 3. Performance of different types of arresters**

Averages are not corrected for size, age, or density of transformers. Probable errors in the individual cases are from 10 to 25 per cent, except for type A, for which only one year's performance is shown

## EFFECTS OF VARIOUS FACTORS

From the results of the investigation certain factors have been found to affect lightning troubles on the distribution system as follows:

### 1. Underground primary mains.

The 1,593 transformers installed in manholes or vaults and connected to underground primary mains had a rate of burnout due to lightning of only $^{1}/_{80}$ of 1 per cent per annum in the past 5 years.

### 2. Grounding of primary neutral.

One advantage of a 4-wire 3-phase system with neutral grounded in the substation is that it permits the installation of 300-volt arresters on the neutral wire of the overhead primary mains and 3-kv arresters on the phase wires, whereas with the neutral ungrounded arresters rated at 3 kv and 6 kv, respectively, are required. During a lightning discharge the 300-volt arresters break down quickly, after which the primary neutral wire acts as a ground wire to reduce the maximum voltage which otherwise would be reached by the primary phase wires. This, together with the use of phase arresters of lower voltage rating gives the grounded neutral system an advantage over systems with ungrounded neutral by a reduction of about 40 per cent in the maximum crest voltage to which the transformers are exposed to induced discharges. This advantage also is indicated by the fact that, although no arresters are installed in substations, flashovers due to lightning in the substations in Chicago are entirely unknown and burnouts of voltage regulators due to lightning in recent years have averaged about $^{1}/_{20}$ of 1 per cent per annum. In addition, the number of cable failures due to lightning has been only about 2 per year though there are 3,800 points of connection to the overhead mains.

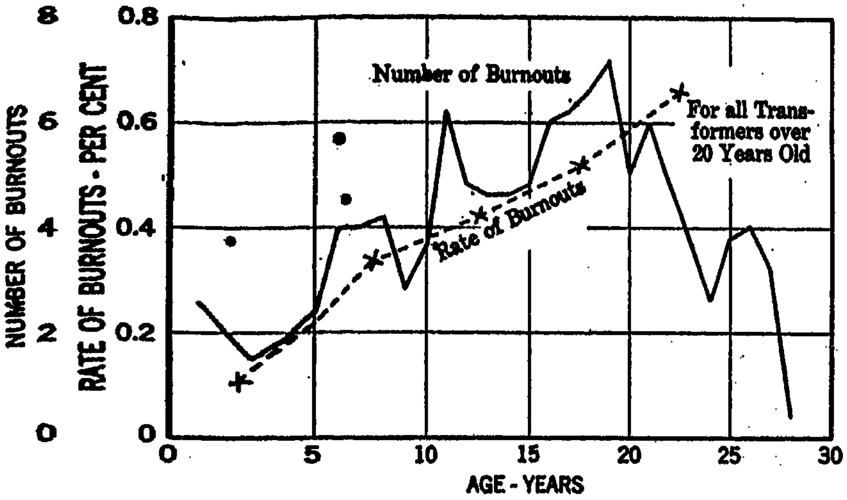

**Fig. 4. Relation between age of transformers and burn-outs due to lightning**

Figures shown are averages for 1927–31

### 3. Density of arresters.

This subject, a most important one, was covered quite thoroughly in the author's 1920 paper "Studies in Lightning protection on 4,000-Volt Circuits—II" (A.I.E.E. TRANS., v. 39, part 2, p. 1395). The conclusion reached in that paper was that "There is a very marked improvement in the effect of lightning arrester protection with an increase in density. . . . "

### 4. Size of transformers.

Recent records confirm statements in preceding papers that lightning troubles decrease with increasing transformer size. In Chicago some reduction of troubles has been effected by discontinuing purchases of transformers of capacities lower than 5 kva.

### 5. Age of transformers.

The rate of burnouts has been found to increase several fold with age of a transformer (see Fig. 4).

### 6. Resistance of arrester grounds.

Records indicate that apparently any extra expense to reduce the resistance of lightning arrester grounds below 50 ohms is not warranted.

### 7. Shielding effect of trees and buildings.

As near as could be determined, the shielding effect of trees, buildings, and other tall objects against induced discharges is practically zero for Chicago conditions. There is no way of determining even approximately the extent to which trees and structures shield the lines against direct strokes.

### 8. Extent and intensity of lightning.

Although each type of arrester was installed in several areas widely scattered over the city, the intensity of lightning in these areas varied from year to year; consequently annual variations in protective characteristics of the arresters were observed, as indicated in Fig. 5. This also indicates that to obtain reliable data from such investigations, a great many arresters must be used and the field trial must extend over several years.

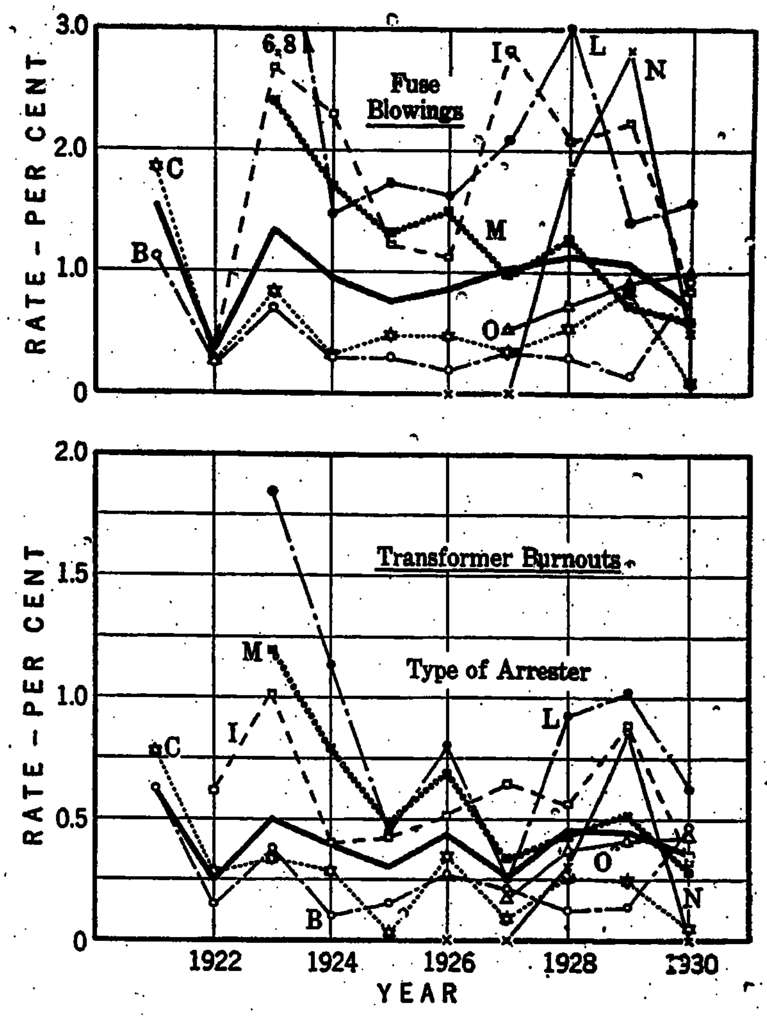

**Fig. 5. (Right) Records of trouble on transformers protected by typical arresters**

Heavy solid line represents average for all arresters on the system

## COMPARISON OF DIFFERENT TYPES OF ARRESTERS

Records indicate that one of the types of arresters (B, Fig. 3) first placed on the market about 20 years ago and withdrawn 10 years later, has not been excelled in its protective efficiency, but its maintenance rate was rather high. It consists of a series of metal gaps with 2 shunting resistors enclosed in a wooden box. At the beginning of 1922 the manufacturers offered valve type arresters in place of the former gap type; these new valve arresters have required about $^{1}/_{3}$ of the rate of replacements that obtain for gap arresters. The ideal valve arrester would be one without a series gap that would discriminate between induced discharges of high frequency and the 60-cycle follow current, opening wide the valve for the former and closing it promptly against the latter, repeating this action year after year without reduction in its protective efficiency.

In recent years several papers have been presented before the A.I.E.E. on the subject of coordination of insulation on transmission lines. These investigations indicate the desirability of similar coordination between lightning arrester performance and the maximum induced discharges to which the distribution transformer windings and bushings are subjected.

## SUGGESTIONS FOR MINIMUM LIGHTNING TROUBLES

1. Use the 4-wire 3-phase system of distribution with grounded neutral.

2. Where transformers or cables are connected to overhead primary mains, install low voltage arresters on the neutral wire and valve type arresters suitable for the Y voltage on the phase wires; avoid duplication within 500 ft, and reduce the number, for Chicago conditions, by $^1/_3$.

3. Use transformers having insulation on the coils and leads that will not deteriorate with age and that will withstand a transient voltage test safely above the voltages to which the transformers will be subjected in service when protected by arresters.

4. If conditions warrant a second ground rod for reducing the resistance of the lightning arrester ground, install also a second ground wire down the pole and connect it to the second ground rod.

5. Select newest transformers for installation in districts of low arrester density and install the older transformers in areas of high arrester density.

6. Require each customer to ground the neutral wire of his house wiring to a water pipe on his premises.

7. Connect the neutral wire of each section of secondary mains to at least 2 ground rods; on long mains install ground rod connections at intervals not exceeding 600 ft.

8. Interconnect, to a reasonable extent, the neutral wires of adjacent secondary mains.

9. Interconnect the lightning arrester ground wire and the secondary neutral wire when the latter is well grounded.

10. Where transformers are connected to primary mains 1,500 ft or more distant from the nearest transformers, install on the pole about 600 ft from the transformers the same lightning arrester equipment as on the transformer pole.

11. Ground the lead sheaths of all underground primary cables.

By following these suggestions and giving the problem continuous engineering supervision, it appears possible to reduce the number of transformer troubles caused by lightning in Chicago, that is fuses blown plus transformers burned out, from 13 cases to less than 1 case of trouble per year per thousand transformers installed.

# II—Experience on a System With High Ground Resistance

By

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FOR YEARS, lightning storms in the territory served by the Edison Electric Illuminating Company of Boston have been accompanied by numerous blown fuses, damaged and burned out transformers, and other troubles, all of which caused many outages to customers with consequent annoyance to them as well as expense to the company. This company distributes electrical energy in 40 cities and towns, embracing 650 square miles in and about the city of Boston. (See Fig. 6.) A total of 325,000 retail customers is supplied from 10,200 distribution transformers. All power customers are fed from 3-phase transformers of which there are 1,500 overhead and 500 underground. Of the single-phase lighting transformers, 7,300 are overhead and 900 underground. In general, the primary distribution system is of the 3-phase 4-wire radial type and operates at 2,300/4,000 volts with the neutral ungrounded. There are approximately 235 such circuits of which about $^1/_5$ of the circuit miles are estimated to be underground.

Prior to 1925, lightning arresters of conventional type had not been used to any extent principally because of the opinion that in order for this equipment to function satisfactorily it was absolutely essential to have low resistance ground connections. Those familiar with New England soil conditions realize that a low resistance ground at the foot of a pole is a rarity. This condition was emphasized in 1917 when the United States Bureau of Standards made a general survey of ground resistance conditions and found that they were worse in New England than anywhere else in the country. (See Bureau of Standards *Publication No. 108,* "Ground Connections for Electrical Systems," by O. S. Peters, June 1918.)

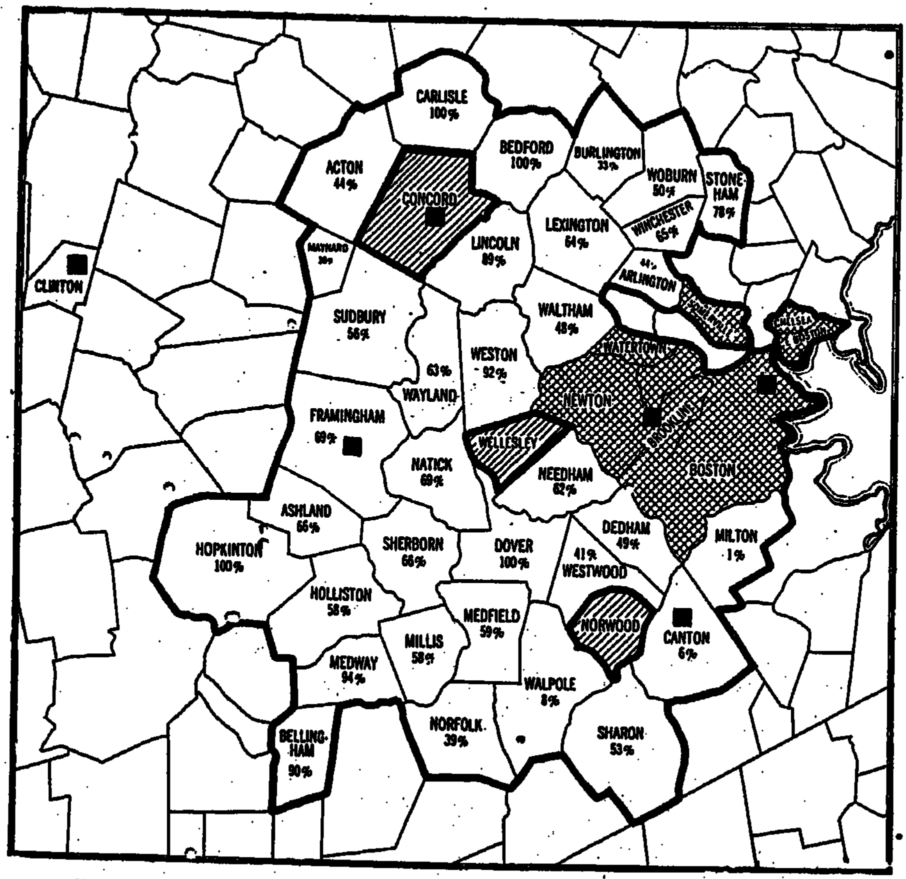

Fig. 6. Territory served by the distribution system of the Edison Electric Illuminating Company of Boston

Single crosshatched areas have municipal distribution. Double crosshatching indicates unprotected area. Black squares indicate observation stations of the U. S. Weather Bureau. Percentages given indicate degree of protection in their respective areas

With the growth of the system, conditions were becoming so acute that early in 1923 it was decided to make a trial installation of several standard lightning arresters notwithstanding the fact that there was little hope of getting what was considered a low resistance ground. The first circuits to be protected were in areas where records had shown

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Based upon "Lightning Protection for Distribution Transformers" (No. 32-44) presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 25–29, 1932.

**Table II—Summary of Troubles on Distribution Transformers Due to Lightning in Protected Area**

| Year | No. of Weather Bureau Lightning Observations | Per Cent Protection | Avg. Ground Resistance | Transformers With Lightning Arresters |  |  | Transformers Without Lightning Arresters |  |  | All Transformers |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  | No. of Transformers | Troubles per 100 Transformers | Troubles per 100 Transformers per 100 Weather Bureau Observations | No. of Transformers | Troubles per 100 Transformers | Troubles per 100 Transformers per 100 Weather Bureau Observations | No. of Transformers | Troubles in Year | Troubles per 100 Transformers | Transformers per 100 Weather Bureau Observations |
| 1927 | 144 | 34 | 201 | 1,484 | 25.5 | 17.7 | 2,836 | 44.4 | 30.8 | 4,320 | 1,637 | 37.9 | 26.3 |
| 1928 | 82 | 38 | 210 | 1,805 | 9.9 | 12.1 | 2,970 | 13.9 | 17.0 | 4,775 | 600 | 12.6 | 15.4 |
| 1929 | 126 | 49 | 196 | 2,407 | 12.1 | 9.6 | 2,487 | 38.0 | 30.2 | 4,894 | 1,239 | 25.3 | 20.1 |
| 1930 | 118 | 56 | 214 | 2,930 | 15.7 | 13.3 | 2,329 | 22.6 | 19.2 | 5,259 | 987 | 18.8 | 15.9 |
| 1931 | 114 | 71 | 234 | 3,781 | 4.2 | 3.7 | 1,562 | 7.6 | 6.7 | 5,343 | 278 | 5.2 | 4.6 |

transformer troubles due to lightning to be most severe.

From past experience certain areas in and closely adjacent to the city of Boston had shown a trouble rate about $^1/_3$ of that of the rest of the territory, or less. There is now a total of 3,400 overhead transformers in these areas, none of which is protected by lightning arresters. As this section is more thickly settled than the rest, its comparatively low rate is thought to be due to the shielding effect of structures. As a result, no protection was intended for these areas and consequently they have been eliminated from the study. The protected area in which there are now approximately 5,400 overhead transformers, is shown in Fig. 6.

## METHOD OF CONNECTING ARRESTERS

Lightning arresters of 3 different manufacturers were selected, each having seemingly desirable characteristics; all had porcelain housings, and were rated for circuits of from 4 to 5 kv. Single-phase transformers, which are connected between a phase wire and neutral, were equipped with 2 arresters, one from each wire to ground; 3-phase transformers, which are connected to each of the 3-phase wires, were equipped similarly with 3 arresters. It was planned to equip about 500 transformer installations per year.

As lightning arrester protection was estimated to cost an average of $50 per transformer, it was not deemed economically justifiable, in general, to install the equipment on transformers under 7.5-kva capacity. As the records showed, however, that transformers on dead ends were more susceptible to lightning troubles than the others, it was decided to protect those as small as 5-kva capacity at these points.

The first group of arresters was installed in 1925. Because of the previously mentioned opinion as to the necessity for low resistance grounds, it was decided for the first trial group that lightning arresters would not be installed unless a ground connection of 250 ohms or less could be obtained. Soon after the work was started, however, it was found that even 250-ohm grounds were difficult to obtain. Consequently in order to be able to complete a reasonable number of installations for observation, the limit for ground resistance above which arresters should not be used was raised to 1,000 ohms.

## RESULTS OF STUDY

No attempt was made to analyze operating records until 1927 as the number of installations in service previous to that time was thought to be too small to obtain reliable data. From the procedure established, it may be noted that in any area selected for protection some transformers were protected and some were not. It was thought that in general this practise would give a means of comparing the performance of transformers protected with that of those not protected. Each year previous to the lightning storm season, all arrester grounds were measured for ground resistance; those over 250 ohms were treated with salt and water and/or had additional rods driven in an attempt to lower their resistances.

A summary of data collected for protected and unprotected transformers, arranged by years from 1927 on, is given in Table II. Results for 1927 show that the installation of lightning arresters on certain transformers decreased all types of lightning troubles on those transformers by 40 per cent, and all troubles except those classified as miscellaneous, by 50 per cent.

During 1928 lightning storms were much less frequent than in the previous year resulting in only about half as many transformer troubles as in 1927. The summary of troubles for this year as shown in Table II indicates that the troubles with protected transformers were much less than the troubles with unprotected transformers.

In 1929, as a result of the previous 2 years' experience, lightning arresters were installed at a more rapid rate and ground resistances up to 2,000 ohms for transformers larger than 10 kva were accepted, although as before, salt treatment was given where possible in an endeavor to lower the resistance of such installations. The summary of results for that year (Table II) shows even more strikingly the effectiveness of protection as in this year there was proportionately more than 3 times as much trouble on unprotected transformers as on protected ones. An analysis of troubles by transformer sizes showed that while transformers 5 kva and smaller constituted slightly less than 30 per cent of all the transformers in service, they accounted for more than 50 per cent of the troubles.

By 1930, 3 consecutive years of study had demon-

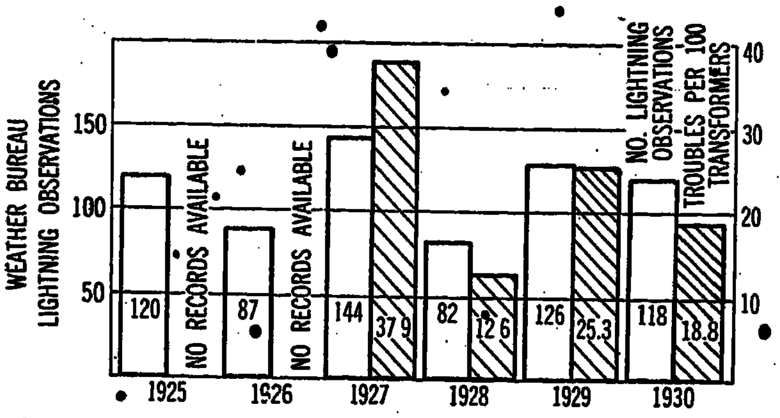

**Fig. 7. U. S. Weather Bureau lightning observations compared to transformer troubles**

strated the effectiveness of the protection afforded by lightning arresters. The fact that proportionately more troubles occurred on transformers of 5 kva and smaller capacity, and that in general the smaller transformers are more remote from maintenance headquarters, together with the improvements shown with increased arrester density, led to the decision that all transformers in towns in the protected area ultimately should be protected.

As a further result of the studies and in an effort to apply the new program most effectively all unprotected transformers where trouble had occurred more than twice in 1929, were equipped with arresters. Also a small group of towns where excessive lightning troubles had occurred were selected and arresters were added to give 100 per cent protection before the 1930 lightning season.

In 1929, as stated previously, it was learned that transformers of small sizes were particularly susceptible to lightning outages. The 1930 analysis brought out the same condition, but more strikingly: Of the total troubles 67 per cent was on transformers of 5 kva and smaller; this group constitutes 28.5 per cent of the total number of transformers.

## DATA CORRECTED FOR STORM SEVERITY

As 100 per cent protection is approached, the means of comparing the effectiveness of the work tends to disappear and a need for some other measure to show the progress being made becomes evident. The United States Weather Bureau records observations of lightning storms from several stations in and about Boston. Lightning observations reported by the bureau have been totaled and called the "storm severity factor"; this factor is used as a divisor to modify the trouble rates in an attempt to render them more comparable. Locations of these observation stations are shown in Fig. 6 while Fig. 7 gives the total number of observations each year compared with the number of transformer troubles in the same year.

Reduction in trouble rate resulting from the application of arresters modified by the storm severity factor, is shown in Fig. 8 plotted against arrester protection in per cent. Extrapolation of the trend curve gives an indication of the improvement that may be expected by further additions of lightning arresters. As may be noted, this trend for the area considered is shown as a straight line. Other curves in Fig. 8 show the reduction in trouble rate for an individual town and for a group of towns; these are given to indicate the effect of complete protection in lowering the trouble rate. These particular towns were selected on account of the severity and frequency of storms in their respective localities.

Using this expectation curve as a basis, it can be shown for this system that the annual saving in cost of maintenance to be expected by the decrease of troubles anticipated from the protection of all the remaining transformers in the protected area, will be sufficient to finance the additional investment required for complete protection. Additional gains will be realized in decreased customer outage and decreased handling and overhead expenses, items not included in the cost analysis.

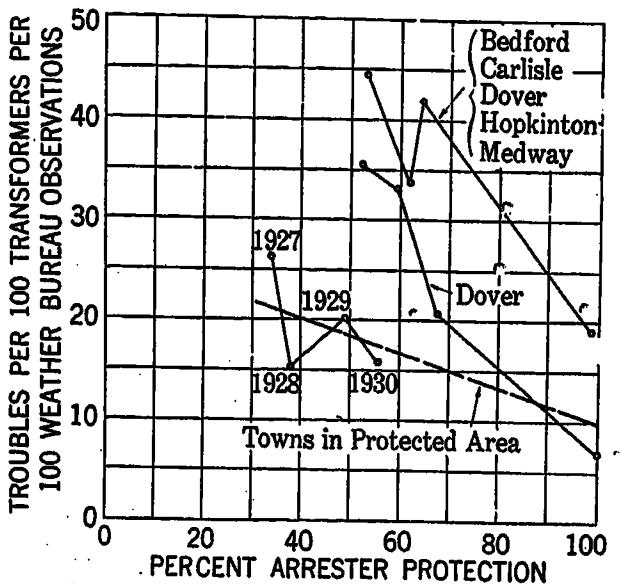

**Fig. 8. Reduction of trouble rate effected by lightning arresters**

## ARRESTER DENSITY AND GROUND RESISTANCE

Studies of the effect of lightning arrester density per unit area and of the effectiveness of various values of ground resistance were begun in 1927 and continued throughout the investigation. Results of these studies are plotted in Figs. 9 and 10, respectively. A distinct improvement as the density increased is indicated by Fig. 9; this seems to check conclusions reached in previous studies. (See "Studies in Lightning Protection on 4,000-Volt Circuits," D. W. Roper, A.I.E.E. TRANS., v. 35, 1916, p. 655; and v. 39, 1920, p. 1895.)

As previously mentioned, the average ground resistance in the area served by this company is high, being over 200 ohms. In Fig. 10 it may be seen that for resistances lower than 100 ohms, decreased resistance makes a definite improvement in the effectiveness of arresters, whereas above that value the effectiveness is not reduced materially by higher ground resistance. The upper horizontal line on Fig. 10 shows the average trouble intensity for unprotected transformers. A comparison of the curves indicates that arresters even with extremely high ground resistances give valuable protection. In the course of early discussion of these data the question was raised as to whether the ground resistance offered to 60-cycle current used for testing might be different from that offered to lightning waves. An investigation made subsequently by one of the lightning arrester manufacturers showed that resistance values offered to lightning waves are appreciably less than those offered to 60-cycle currents. (See "Impulse Characteristics of Driven Grounds," H. M. Towne, *G.E. Rev.*, Nov. 1928.) This may account to a certain extent for the relative effectiveness of ground connections having high 60-cycle resistances.

As stated previously, lightning arresters from 3 manufacturers were used. Records of troubles were segregated and tabulated by manufacturers throughout the investigation. A comparison of these data show that for conditions as found on this system there is little to choose between the different arresters.

During 1930 careful inspections were made of nearly all the transformers where fuses had been blown during lightning storms. Evidence of arcing was found in nearly every case. The arcing seemed to be concentrated on those transformers which were of somewhat ancient design with small primary bushings, insufficient internal clearances, primary terminal boards, etc. Tabulation of the results indicated that transformers made previous to 1910 gave several times as much trouble as those manufactured since then. Inasmuch as previous to this date high-loss iron for the transformer cores was used quite generally, the policy has been adopted of eliminating these old transformers from the system. All other transformers passing through the shop are rebuilt to increase internal clearances and are equipped with modern bushings.

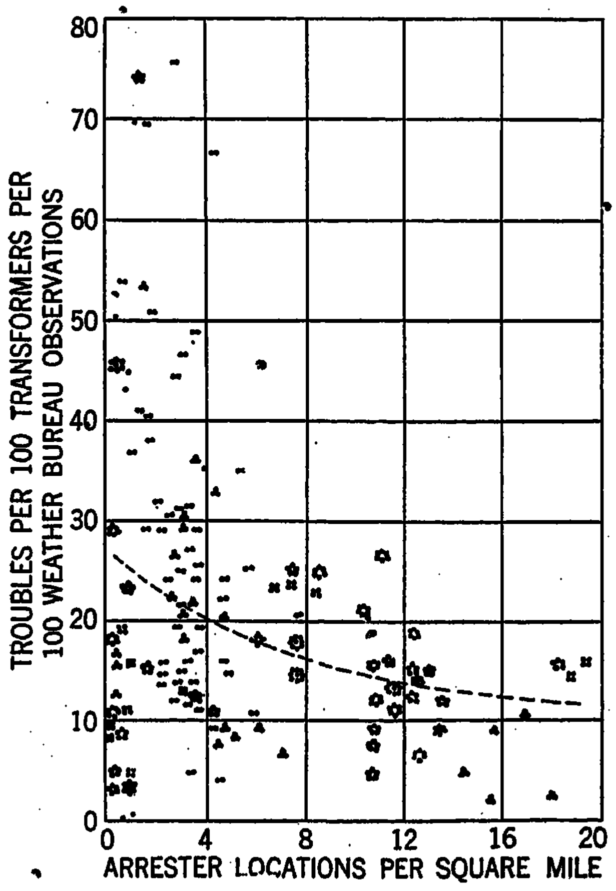

**Fig. 9. (Left) Variation of transformer trouble rate with lightning arrester density, 1927–30**

## SHIELDING EFFECT OF STRUCTURES

During 1930 additional data were obtained which indicated that the shielding effect of structures and other conductors may have a more pronounced effect in protecting transformers and fuses against lightning outage than previously had been recognized. Thus the trouble rate in any area appears to be influenced by a combination of the effects of shielding and arrester density, each of which contributes its share to the final result.

## RESULTS OF 1931 STUDY

While the data for the year 1931 have not been studied carefully on account of lack of time, the summary in Table II shows a marked decrease in the total number of troubles as well as in the trouble rate. Again the rate of trouble on protected transformers is less than half that of the unprotected. The marked decrease in troubles is due in part to the rebuilding of about 25 per cent of the transformers and the removal from the system of most of the small transformers built prior to 1910. It should be noted that the improvement in operation of the protected transformers in general remains the same as in previous years even with nearly all the small trouble-making transformers removed from the system.

## CONCLUSIONS

On the basis of results obtained to date, the following conclusions seem justifiable for this system:

1. Application of lightning arresters to line transformers in areas affected by lightning reduces the trouble rate by about 50 per cent.

2. Variation in ground resistance within the values readily obtainable in this territory has slight effect on the efficiency of arresters.

3. The value of treating grounds or the installation of multiple grounds in an effort to lower resistance is questionable unless by so doing the resistance can be lowered to about 100 ohms or less.

4. Insufficient electrical clearances in the smaller and older transformers are an important source of lightning trouble. Larger bushings and greater clearances are clearly indicated to be necessary features of correct transformer design.

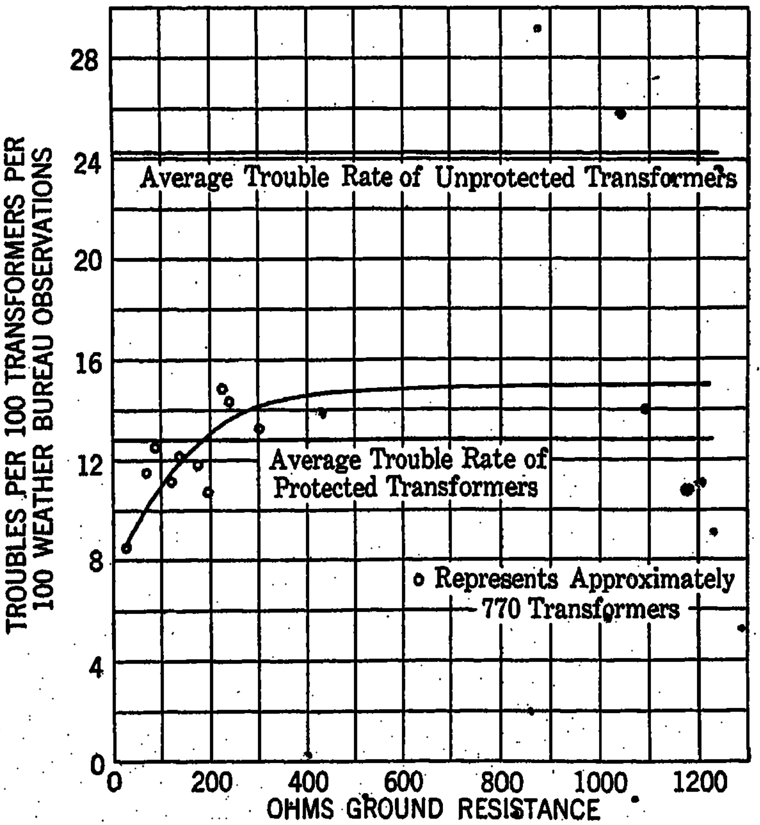

**Fig. 10. Variation of transformer trouble rate with arrester ground resistance, 1927–30**

# III—Experience on a Diversified System

By
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INVESTIGATIONS of lightning troubles have been conducted on the distribution system of the Philadelphia Electric Company since 1921. Their purpose has been to determine: (1) magnitude and nature of trouble in various localities; (2) effectiveness of lightning arresters under field conditions; and (3) ways and means for improving service continuity. Up to and including 1929, studies were confined to the Philadelphia division. In 1930 they were extended to the entire system which includes 6 operating divisions having in service approximately 23,000 aerial transformers.

During the period 1921–29, investigations were confined to the analysis of fuse blowings and transformer failures. Comparisons of trouble on protected and unprotected transformers (reduced to a common basis of troubles per 100 transformers in service) appeared to indicate that lightning arresters were not providing satisfactory protection. This was attributed to the relatively high resistance of the arrester grounds, which average well over 100 ohms.

In 1930, the studies not only were extended to all operating divisions of the system but also were broadened to include many factors which from past experience appeared to be of major importance. Also in 1930 these studies were extended to the territory of the former Philadelphia Suburban-Counties Gas & Electric Company, and of the Susquehanna Utilities Company. This permitted investigations on a variety of types of distribution systems as follows:

1. 2.3-kv, 2-phase, 3-wire, ungrounded.
2. 2.3-kv, 3-phase, 3-wire, ungrounded, Δ-connected.
3. 4.1-kv, 3-phase, 4-wire, grounded, *Y*-connected.
4. 6.6-kv, 3-phase, 3-wire, ungrounded, Δ-connected.

From observations thus far it has been impossible to detect any difference in susceptibility to lightning between grounded and ungrounded systems.

## SUMMARY OF LIGHTNING TROUBLE, 1930–31

During 1930, approximately 5 per cent of the transformers on the combined system experienced lightning trouble. Of these, 68 per cent represent transformer fuse and fuse box trouble, and the remainder transformer (bushing, lead, or winding) trouble. Similar conditions were found to exist in 1931 also. Lightning trouble data for these 2 years are summarized in Tables III and IV.

In the light of these experiences, several different factors which appear to be of major importance to the lightning protection problems as a whole next will be discussed. This discussion is based largely upon experience in the Philadelphia division, for which more complete information was obtained than for the other divisions.

**Table III—Summary of Transformer Lightning Trouble—1930**

| Division | Transformers | | | Troubles per 100 Transformers | | |
|---|---|---|---|---|---|---|
| | No. in Service | Average Size, Kva | Total Troubles | Fuse and Fuse Box | Transformer | Total |
| Philadelphia | 8,467 | 32.8 | 230 | 1.5 | 1.2 | 2.7 |
| Eastern | 4,204 | 9.5 | 250 | 4.2 | 1.8 | 6.0 |
| Schuylkill | 3,830 | 9.7 | 69 | 0.6 | 1.2 | 1.8 |
| Main Line | 3,043 | 10.7 | 220 | 5.1 | 2.1 | 7.2 |
| Delaware | 2,299 | 22.3 | 20 | 0.0 | 0.9 | 0.9 |
| Susq. Utilities | 958 | 6.0 | 275 | 26.2 | 2.5 | 28.7 |
| Total System | 22,801 | 19.5 | 1,064 | 3.2 | 1.4 | 4.6 |

**Table IV—Summary of Transformer Lightning Trouble—1931**

| Division | Transformers | | | Troubles per 100 Transformers | | |
|---|---|---|---|---|---|---|
| | No. in Service | Average Size, Kva | Total Trouble | Fuse and Fuse Box | Transformer | Total |
| Philadelphia | 8,321 | 32.8 | 183 | 1.3 | 0.9 | 2.2 |
| Eastern | 4,581 | 10.1 | 317 | 3.1 | 3.8 | 6.9 |
| Schuylkill | 3,863 | 10.2 | 190 | 2.8 | 2.2 | 5.0 |
| Main Line | 3,197 | 11.4 | 221 | 4.2 | 2.7 | 6.9 |
| Delaware | 2,475 | 20.3 | 49 | 0.2 | 1.8 | 2.0 |
| Susq. Utilities | 1,182 | 6.0 | 96 | 7.2 | 0.9 | 8.1 |
| Total System | 23,619 | 19.2 | 1,056 | 2.5 | 2.0 | 4.5 |

## SIZE AND AGE OF TRANSFORMERS

Trouble was found to decrease with increasing size of transformers (see Fig. 11). The greater trouble on small transformers is believed to be due largely to (1) small clearances between leads and case, and (2) smaller bushings, thus permitting more flash-overs at these points with resultant short circuits. The age of a transformer appears to have but little effect upon its trouble rate except on sizes of 5 kva and less; also the newer transformers are less susceptible to lightning troubles than the older ones. Therefore, a reduction in trouble should result if the smaller transformers be replaced by larger ones or by ones of like size of recent design.

## ARRESTER AND FUSE PROTECTION

Analysis of arrester performance, neglecting transformer size, has shown consistently during the past 5 years that arresters apparently effected little reduction in trouble. However, the same data, when analyzed with respect to transformer size, based upon cases of trouble on various size-groups, indicates that

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Based upon "Distribution System Lightning Studies by Philadelphia Electric Company" (No. 32-20) presented at the A.I.E.E. winter convention, New York, N. Y., January 25–29, 1932.

transformers having capacities of 15 kva or less were not benefited materially, but that those of more than 15 kva capacity showed a considerable reduction in trouble. (See Fig. 12.) The apparent poor performance of arresters on small transformers may be due to the relatively low voltage breakdown of transformer leads to case resulting from small clearances; the breakdown voltage of the transformer leads may approach too nearly that of the arresters. It is believed this applies particularly to the older transformers.

Fuse size has an important bearing upon the number of fuse blowouts during lightning storms. In the Philadelphia division and in the area served by Susquehanna Utilities Company these troubles were reduced materially by changing from small to large fuses; no appreciable increase in transformer failures resulted from this change. Former practise was to protect against overload by fusing at 1 amp per kva of transformer capacity. At present, fusing against short circuit is general practise throughout the system.

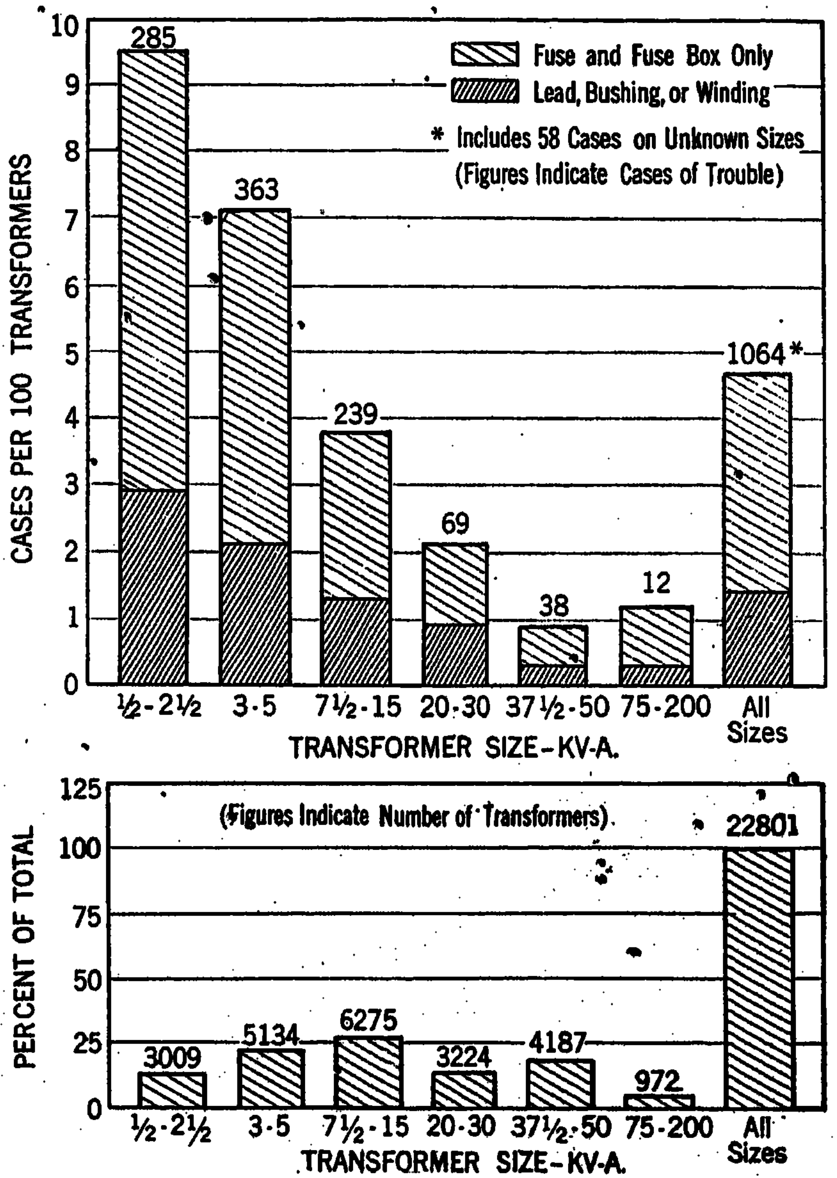

**Fig. 11. Fuse and transformer lightning troubles on aerial portion of Philadelphia Electric Company distribution system (above) compared to number of transformers in service (below)**

LIGHTNING STORM SEVERITY; SHIELDING

Approximately 45 per cent of the total distribution system lightning trouble for 1931, up to September 1, occurred during one storm (July 14) although there were 20 or more other storms during this period. This, with similar experience in previous years, indicates the number of storms to be an unsatisfactory measure of over-all lightning severity for any given year. At present, practical methods for measuring lightning severity are not available. It is desired to stress the need of suitable devices for this purpose.

Regarding "exposed" and "unexposed" locations, thus far it has not been found possible to establish any satisfactory relation between trouble experienced from lightning, and shielding provided by trees, tall buildings, or topography. However, it is felt that this may be a significant factor, since where shielding prevails, less lightning trouble is likely to result.

EFFECT OF GROUND RESISTANCE

Theoretically, the lower the arrester ground resistance the greater will be the reduction in surge voltage while the arrester is discharging. This fact, together with the favorable performance of arresters where ground resistances have been reduced to about 15 ohms or less on this company's 13.2-kv lines, is largely responsible for the effort directed toward improving grounds.

Measurements of single driven grounds widely distributed throughout the system indicated an average ground resistance of the order of 100 ohms. Accordingly, consideration was given in 1931 to the following methods of improving grounds:

1. Salt treatment.
2. Multiple ground rods.
3. Connection to water system.
4. Connection to secondary circuit grounded neutral.

Methods 2 and 4 were experimented with as discussed in the following paragraphs.

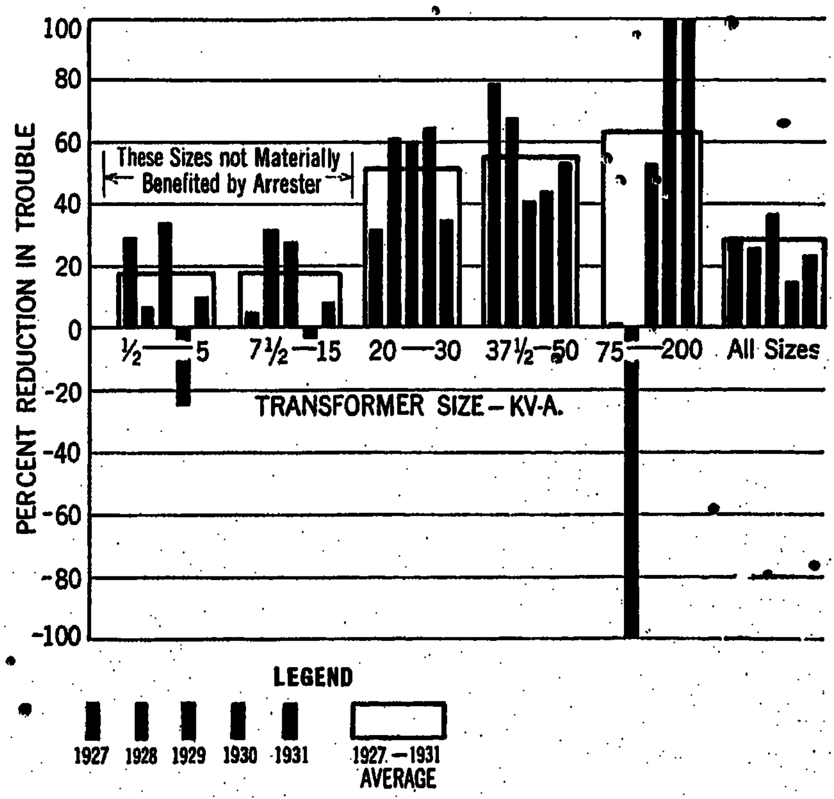

**Fig. 12. Reduction in distribution system troubles effected by primary lightning arresters**

### MULTIPLE GROUND RODS

In northeast Philadelphia where lightning trouble was serious, 345 installations of ground rods in multiple with existing arrester grounds were completed in July 1931. With a maximum of 4 additional rods per installation, it was possible to reduce 45 per cent of the grounds, many of which originally exceeded 50 ohms, to less than 15 ohms; all were reduced to less than 50 ohms. Up to September 1, 1931, 8 cases of trouble had occurred at these locations. Of these 8 cases, 7 occurred where the ground resistances exceeded 15 ohms. Expressed as troubles per 100 transformers, these data indicate only 13 per cent as much trouble where ground resistances were less than 15 ohms, as where ground resistances were higher than that value. However, this experience covers but a very short time and hence the results cannot be considered conclusive.

Multiple rods were installed also in an area outside of Philadelphia where lightning troubles had been even more serious than in the Philadelphia division. In that area 266 installations of multiple rods were completed in June 1931. While essentially the same reduction in resistance was obtained as in Philadelphia, experience in the 2 situations differed to the extent that the trouble rate was the same for ground resistances both above and below 15 ohms. This apparent difference in arrester performance in the 2 areas is believed to be due to the relatively small transformers in the area outside of Philadelphia, averaging about 4 kva in capacity compared with an average of 15 kva in Philadelphia. As previously discussed, studies have shown that but little protection can be obtained for the small transformers.

### CONNECTION TO SECONDARY GROUNDED NEUTRAL

Because of its low cost and added advantage of tending to equalize surge potentials on both primary and secondary sides of transformers during arrester discharges, connection between the primary arrester ground wire and the secondary circuit grounded neutral has been studied. Trial installations of this connection, hereafter called the "neutral tie," were completed early in June 1931 at 151 locations, involving 179 transformers. (See Fig. 13.) For comparative results these were concentrated in an area adjacent to where multiple rods were installed in Philadelphia, and in which lightning trouble had been equally severe. The use of the neutral tie was restricted to locations where the secondary neutral ground resistance measured less than 15 ohms and where the secondary circuit fed 10 or more customers whose service neutrals were grounded to water pipes.

Up to September 1, only one case of trouble, a transformer fuse blowout, occurred at neutral tie locations. This trouble was not accompanied by trouble on the secondary circuit or customers' equipment. Protected transformers in this area without the neutral tie had approximately the same rate of trouble. Unprotected transformers experienced considerable trouble, indicating that this area had been exposed to lightning storms of at least moderate severity. Although this experience over a short period of time indicates the feasibility of the neutral tie, observations over a long time and with a larger number of installations must be obtained before dependable conclusions can be drawn.

Analysis of customer meter trouble due to lightning during one severe storm indicated less trouble on secondary circuits fed from transformers with the neutral tie than on those from unprotected transformers. This indicates the neutral tie did not aggravate secondary trouble and, therefore, imposed no additional hazard on person or property.

### RELATION OF PRIMARY TO SECONDARY TROUBLES

To determine the relative magnitude of primary and secondary system troubles during lightning storms an analysis of these was made for the unusually severe storm of July 14, 1931. Troubles occurring during that storm were selected for study because there was an unusually large number of them and because information concerning them was concentrated in the records. Later the troubles during this storm were found to constitute approximately 70 per cent of the total 1931 primary system troubles in Philadelphia. These troubles together with the estimated number of resulting customer interruptions are summarized in Table V. Correlating the 138 cases of customers' meter trouble with the cases of primary system trouble, shows that only 2 of the former occurred on secondary circuits fed by transformers experiencing primary trouble. Accordingly,

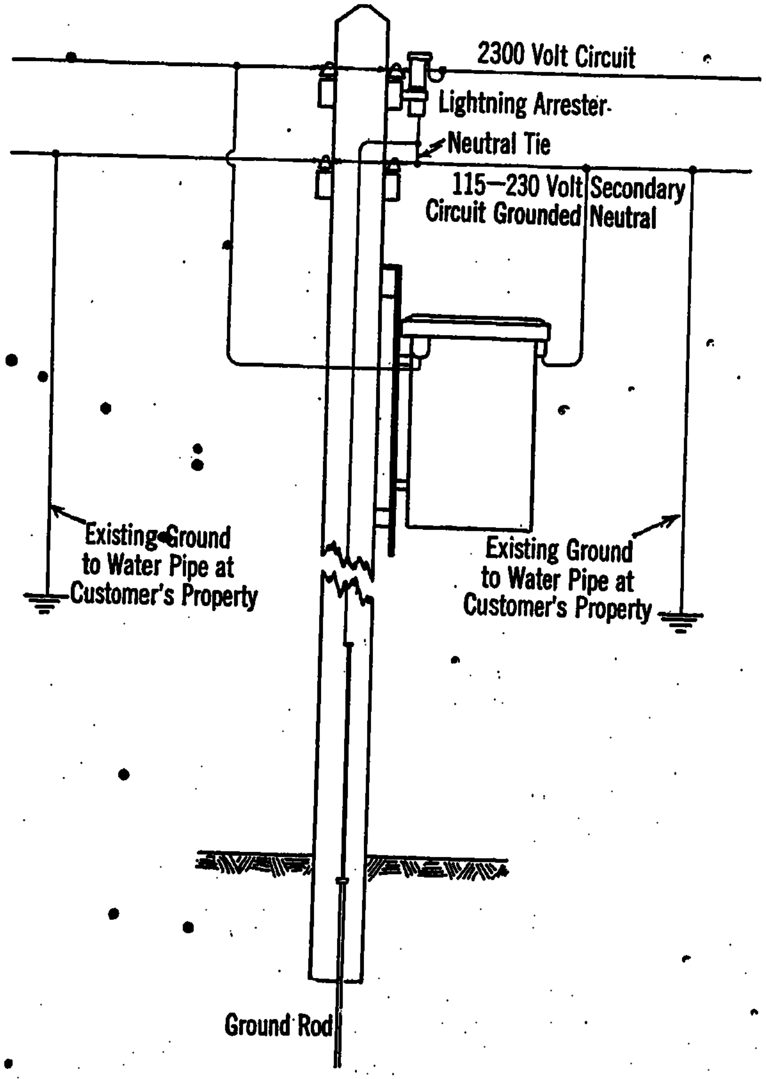
2300 Volt Circuit
Lightning Arrester
Neutral Tie
115—230 Volt Circuit Grounded
Secondary Neutral
Existing Ground to Water Pipe at Customer's Property
Existing Ground to Water Pipe at Customer's Property
Ground Rod

**Fig. 13. Method of interconnecting arrester ground wire and secondary circuit grounded neutral, Philadelphia division**

secondary circuit trouble must be due largely to disturbances originating on that circuit.

It is evident from the causes of customers' interruptions that greater over-all improvement in service continuity may be accomplished by attacking the primary rather than the secondary situation. However, from the viewpoint of the individual customer, interruptions from secondary trouble are equally as important as those caused by primary trouble. Therefore, efforts should be directed also toward reducing the secondary troubles.

## ANALYSIS OF CUSTOMER-HOUR INTERRUPTIONS

Primary circuit and individual transformer interruptions exceeding 5 minutes in duration throughout Philadelphia and suburban divisions in 1931 to September 1 were analyzed to determine the relative magnitude of (1) those during lightning storms and those during other periods; and (2) those due directly to lightning disturbances and those due to other causes, such as wind, trees, etc., during lightning storms. Results of this analysis are shown in Fig. 14 where interruptions are expressed in customer-hours and classified according to character of trouble. These results show that (1) of the customer-hour interruptions exceeding 5 minutes from all causes, more than 80 per cent occurred during lightning storms; and (2) of those during lightning storms, at least half are due directly to lightning disturbances. It appears, therefore, that protection of distribution systems against lightning is of major importance in bettering service continuity.

**Table V—*Primary and Secondary Trouble and Estimated Customer Interruptions Due to a Severe Lightning Storm**

| Classification of Trouble | Number of Cases | Estimated Customer Interruptions |
|---|---|---|
| **Primary System (2.3 kv)** | | |
| Transformer fuse and fuse box | 69 | 4,140 |
| Transformer winding | 30 | 1,800 |
| Transformer lead | 27 | 1,620 |
| Primary wires down | 27 | 16,200 |
| | 153 | 23,760 |
| **Secondary System (115/230 volts)** | | |
| Customers' service fuses blown | 1,200 | 1,200 |
| Cusomers' defective apparatus, appliances, cords, and wiring | 300 | 300 |
| Meters damaged | 138 | 138 |
| Outside (external to service connections) | 90 | 90 |
| Service pipes | 2 | 2 |
| | 1,730 | 1,730 |

* For Philadelphia division only; excludes service lost due to circuit interruptions at substations.

## SUMMARY AND CONCLUSIONS

From the foregoing experience, the following conclusions are reached:

1. Annually about 5 per cent of the 23,000 aerial distribution transformers experienced trouble in some degree due to lightning. Small transformers have been found more susceptible to lightning disturbances than large ones. As far as practicable, the larger transformers should be used, or the older units replaced with more recent ones of the same size.

2. Differences in susceptibility between transformers of different sizes must be recognized when analyzing arrester performance. Observations over 5 years show little benefit from arresters when considering transformers of all sizes collectively. However, taking size into account, these same data indicate that arresters afforded little benefit to those of 15 kva and less capacity, but substantial benefit to the larger sizes.

3. Many factors influence lightning trouble on distribution systems. It is important to consider all of the major ones if reasonable conclusions are to be reached. Also, to permit comparisons with other studies, it is important to have data reduced to a common basis. One method is to compare performance per 100 transformers.

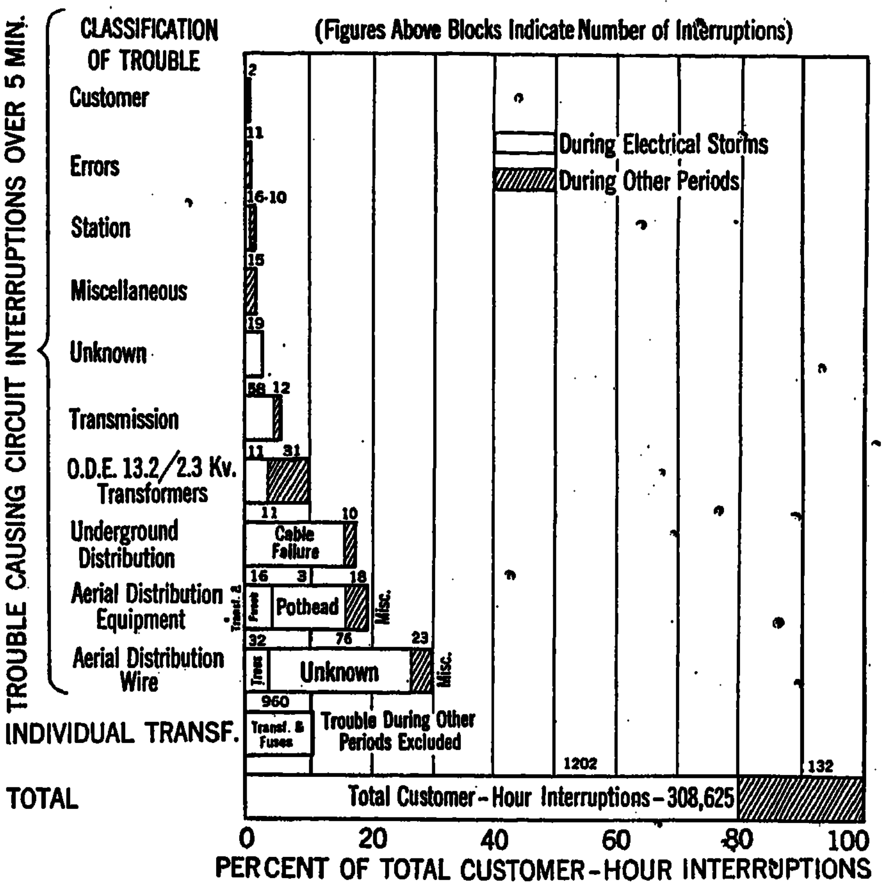

Fig. 14. Estimated customer-hour interruptions due to primary distribution system outages for the first 8 months of 1931; estimates are for Philadelphia and suburban divisions

4. Because of the many factors involved, it has not been possible thus far to determine whether there is a material difference in susceptibility to lightning trouble on grounded and ungrounded systems.

5. Low ground resistance, which theoretical and field studies show to be essential to effective arrester performance, may be obtained at low cost by connecting the arrester ground wire to the secondary circuit grounded neutral; however, where this is done, secondary neutrals should be grounded effectively. Limited field experience shows that this method furnishes satisfactory protection against transformer failure without introducing additional troubles on the secondary system.

6. Customer interruptions from trouble on the primary system far exceed those from trouble on the secondary system. Therefore, major improvement in service continuity can be accomplished best by attacking the primary situation. However, service reliability as measured by the customer is independent of the source of trouble, and consequently improvements on the secondary system cannot be neglected.

7. The number of customer interruptions of a duration less than 5 minutes greatly exceeds those of more than 5 minutes. However, based upon customer-hour interruptions, the latter greatly exceeds the former.

8. The majority of customer-hour interruptions from all causes occur during electrical storms. Of these, this study shows that at least half are directly attributable to lightning disturbances.

9. In the interest of improving service continuity, lightning protection of distribution systems has been found to be of major importance and can be justified economically only from this point of view. Minimizing inconveniences to customers, although of intangible value, nevertheless is highly important and should be carefully considered when establishing policies and practise in solving the lightning protection problem.

# Kaplan Turbines at Safe Harbor Hydroelectric Plant

**One of the numerous features of more than usual interest of the Safe Harbor hydroelectric development is the use of Kaplan turbines having automatically adjustable blades. This type of turbine is used in all of the 6 units of the initial installation, each rated at 42,500 hp under a rated head of 55 ft. Engineering studies in connection with these units required the construction of a new hydraulic laboratory for testing model turbines.**

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MANY new and interesting problems arose in connection with the design and installation of the Safe Harbor turbines. As in any pioneering development of this magnitude, an unusual amount of experimental and engineering study was necessary involving not only the hydraulic and mechanical design of the plant but affecting the structural and electrical design as well.

Limited experience in this country with propeller type turbines caused the Safe Harbor management to feel that certain important operating and engineering information was essential to justify a large expenditure in this comparatively new type of turbine. This feeling was intensified by the fact that the manufacturers had to build wheels considerably larger than had been built before. Furthermore, each of the various manufacturers had offered for consideration several different designs for which no comparative data as to cavitation limitations were available.

Final design of the power house structure depended upon the decision as to the elevation of the turbine runner. The position of the runner with respect to the tailwater elevation would affect materially the power rating of the turbine as limited by cavitation; obviously the economics of the power house substructure and excavation could be determined only after the power limits of the various runners were known. The absence of a hydraulic testing laboratory in this country in which cavitation tests could be made led to the construction of such a laboratory at Holtwood, Pa., adjacent to the Holtwood hydroelectric plant.

### WHY KAPLAN TURBINES WERE ADOPTED

During the early engineering studies an investigation was made of the various types of turbines suitable for the Safe Harbor development which has a relatively low operating head, limited storage, wide fluctuations in river flow and operating head, and where peak load rather than base load is of prime importance.

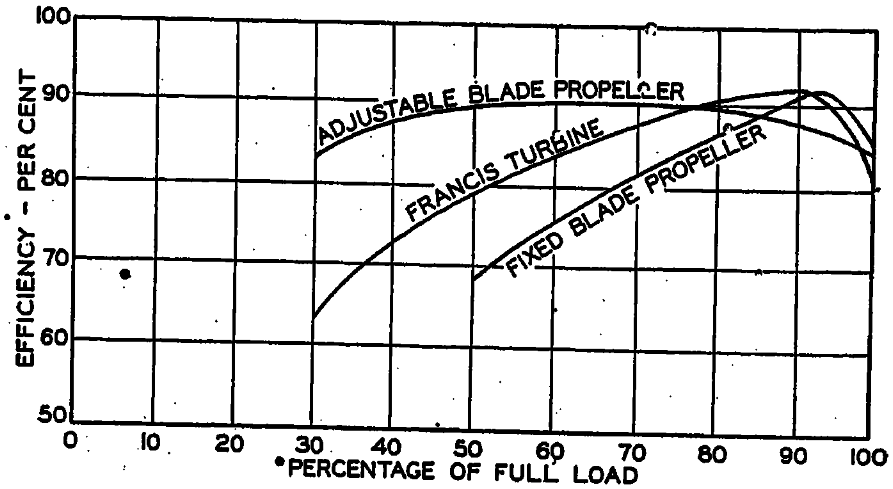

**Fig. 1. Comparative efficiencies of 3 types of turbines**

9,500-hp turbines operating under a head of 38 ft; adjustable blade propeller running at 164 rpm.; fixed blade propeller, 150 rpm; Francis turbine, 100 rpm

Appreciable savings in the cost of power house structures were found possible by using the propeller type of turbine of either the fixed or adjustable blade type. Further savings in the cost of the electric generators were obtainable with propeller turbines because their higher speeds permitted the use of smaller and consequently lower cost generators and direct connected exciters. (See "Hydraulic and Electrical Possibilities of High Speed, Low Head Developments," by Jessop and Powel, A.I.E.E. TRANS., v. 50, 1931, p. 114–9.)

The automatically adjustable blade propeller turbine has certain additional advantages over the fixed blade propeller type: It has a high efficiency over a greater range of loads (see Fig. 1); it can be operated considerably above its normal power rating for short periods of time without an appreciable loss in efficiency; it has materially greater output when operating under reduced heads; it is more stable when operating at part loads. However, on account of the additional mechanism required for blade adjustment, Kaplan turbines are more expensive, both in first cost and in maintenance.

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Based upon "Safe Harbor Kaplan Turbines" (No. 32-124) to be presented at the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., October 10–13, 1932.

The final decision to use Kaplan turbines in *all* of the initial units, rather than using 1 or 2 Kaplan units and fixed blade propeller turbines for the others resulted from a consideration of the operating requirements of this plant. With a run-of-river plant such as Safe Harbor where the maximum discharge of the initial 6 units will be approximately 50,000 cfs, which flow is available for only about 3 months in an average year, the plant obviously will operate as a peak load plant for the greater part of the time. Such operation involves rapid changes in load. During extreme low-flow seasons, when the reservoir will be drawn down on a periodic schedule, there will be a wide variation in the operating head on the plant. When the normal river flow is less than the usable flow through the plant, water is valuable and high operating efficiency at part load is desirable, for water thus saved replaces steam capacity as well as steam energy on the system.

High part-load efficiencies are particularly important on a system where the spare capacity may be carried at the hydro plants. Furthermore, the Safe Harbor plant soon will be the point of interconnection of several major electric systems and undoubtedly there will be periods when split bus operation will be expedient. With such operation Kaplan turbines are the more economical. Maximum efficiency at full rated load is not essential, since during low river flow rated output would be required for but short periods, while at high river flow, when there is an abundance of water, efficiency is not important. Maximum output for short periods and particularly during flood conditions when the back water materially reduces the operating head at the plant is of particular value. Maximum operating economy and flexibility could best be obtained by using turbines all of the Kaplan type. Certain further advantages always accrue through the use of a single size and type of unit in any plant as it requires a minimum of spare parts to be carried, and minimizes hazards from operation and maintenance.

## DESCRIPTION OF UNIT

A cross section through one of the Safe Harbor turbines is shown in Fig. 2. The runner of the turbine is 220 in. in diameter and has 5 blades. These blades can be rotated about a horizontal axis from approximately a horizontal position for no load operation, to an angle of 30° for maximum loads. The throat ring is spherically shaped to permit this movement with a minimum of clearance between blades and ring, reducing the amount of leakage.

Operating mechanism for changing the blade angle position is located in the hub and hollow shafting of the wheel. Each blade is connected through a link to a main head in the runner hub which is connected by an inner shafting to a large "servo-motor" located just below the unit thrust bearing. Oil pressure obtained from the main governor system is carried to this servo-motor through the "Kaplan head" (on the top of the generator shaft) from the operating valve shown at the right of the main unit. An actuating rod connects the wicket gate operating ring with this valve to maintain a definite predetermined position of runner blade for each wicket gate opening. The correct relationship between gate opening and blade angle was found from tests, and is maintained by a specially shaped cam interposed in the actuating rod between the gate operating ring and the runner blade operating valve. This cam can be changed readily for variations in operating head inasmuch as to maintain best efficiency requires a different relationship for each head.

The intake section of the unit has a horizontal floor constructed at the same elevation as the river bottom in the forebay; side walls are parallel and the roof is bell shaped at the entrance. The center line of the turbine was offset from the center line of the intake 2.0 ft for reasons discussed later. The elbow draft tube has a V-shaped roof toward the discharge end, and an appreciable angle of upturn in the horizontal leg to reduce to a minimum the amount of tailrace excavation.

## HOLTWOOD HYDRAULIC LABORATORY

The hydraulic test laboratory at Holtwood, Pa., was designed for testing model turbines 16 in. in diameter (approximately $^1/_{14}$ the size of the actual Safe Harbor units) with complete wheel setting and water passages including intake, scroll case, wheel casing, and draft tube, under a range in test head varying from 4 to 60 ft. For cavitation tests the

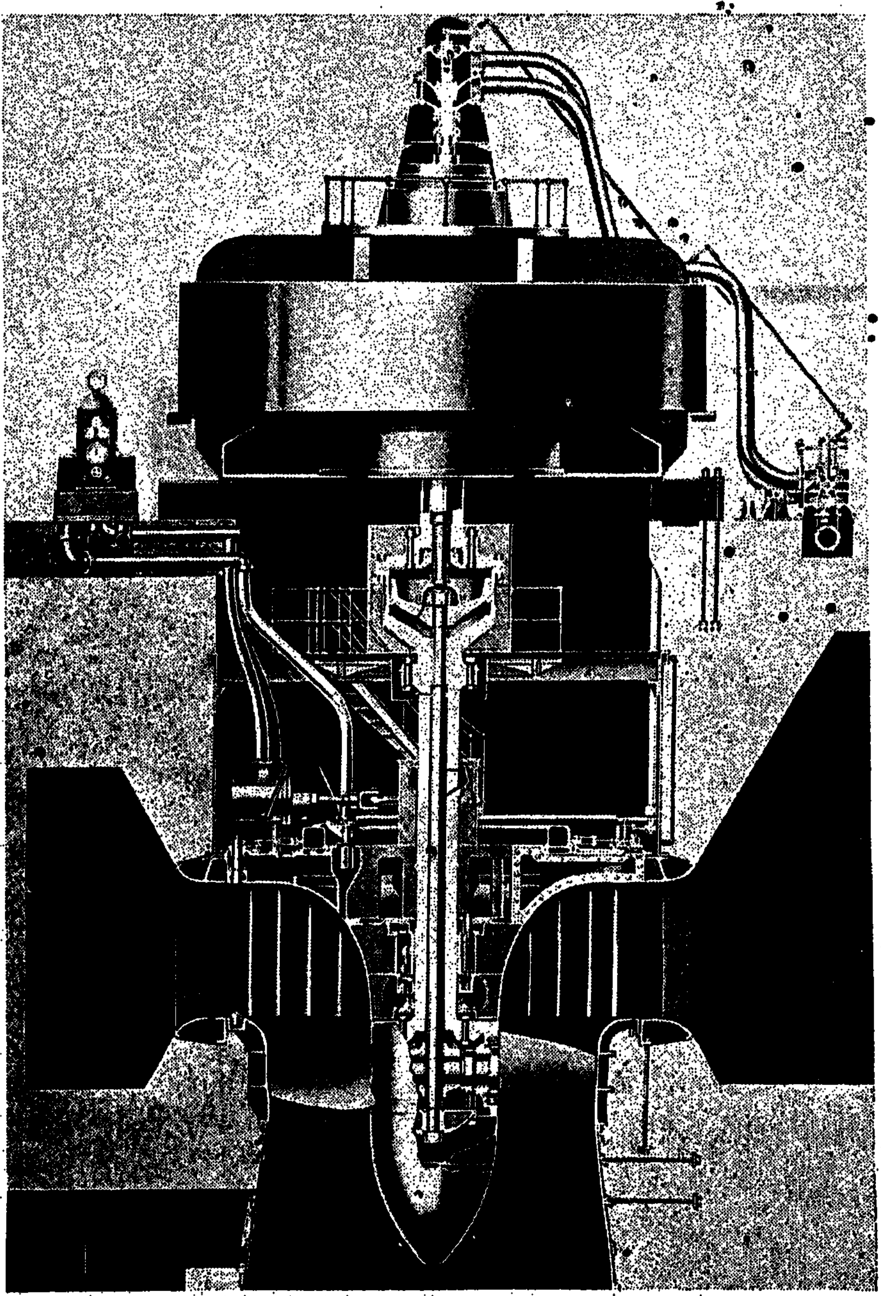


Fig. 2. Cross-section through a Safe Harbor turbine

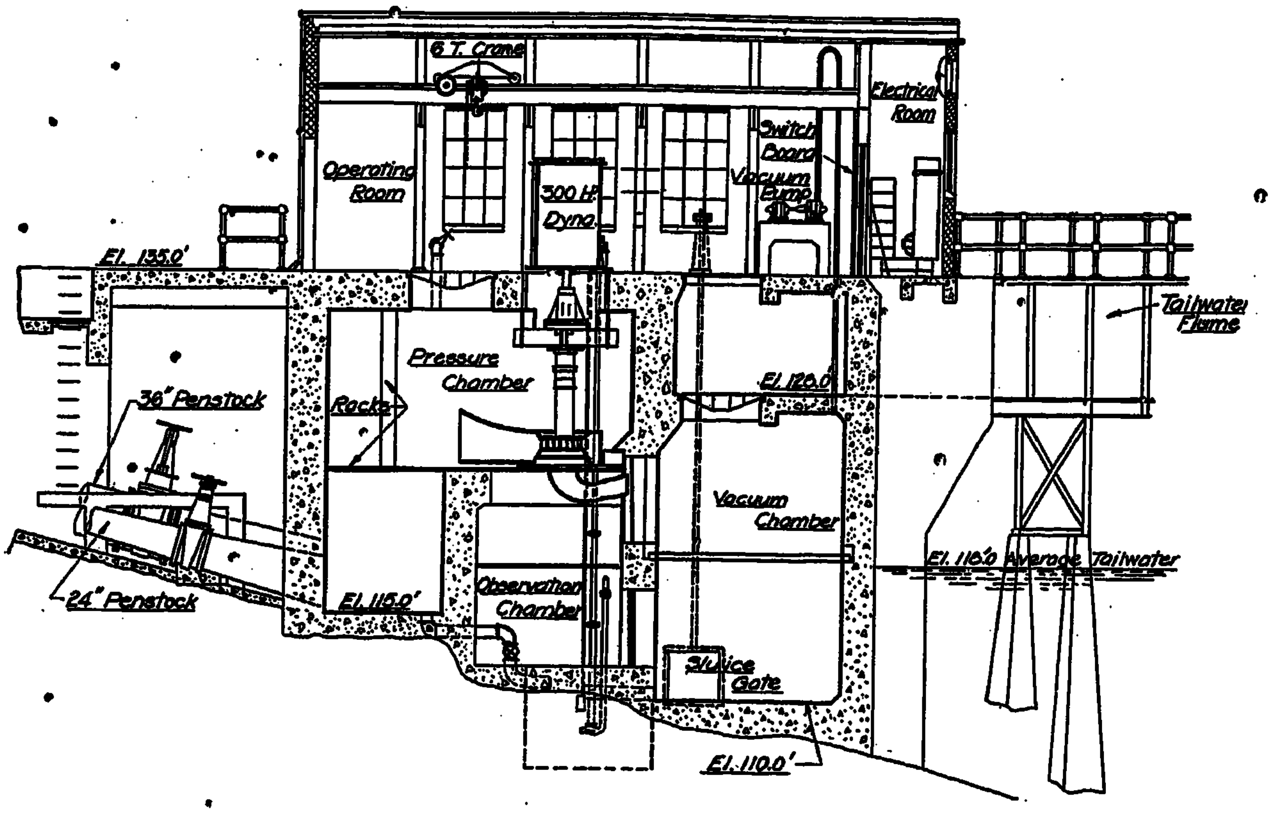


**Fig. 3. Longitudinal section of Holtwood hydraulic laboratory**

draft head may be varied from approximately 10 ft pressure head to 10 ft suction head. A cross-sectional view of the laboratory may be seen in Fig. 3.

The maximum head at the Holtwood plant is slightly less than 60 ft, but since, for cavitation tests it is necessary to vary the suction head over a wide range while holding the total head the same, it was found impossible to get the desired range of heads by using the available drop between the Holtwood forebay and tailrace. A high-head tank therefore was built, into which water can be pumped to an elevation approximately 20 ft above the normal level in the Holtwood forebay, for which purpose a 20,000-gpm constant-discharge pump is used. The water in excess of the amount required in the laboratory is bypassed back into the Holtwood forebay by means of a sluice gate operated by remote control from the main laboratory. By manipulating this sluice gate any desired forebay elevation may be quickly obtained and held constant. From this tank the water flows through a 36-in. penstock to the pressure chamber in the laboratory. After entering, the water must pass through a series of baffles which remove whirls and eddies and insures uniform velocity distribution as the water approaches the intake passages of the turbine. The pressure chamber was designed sufficiently large to accommodate the complete wheel setting. Water passes from the draft tube into a vacuum chamber, so called because a vacuum pump connection permits operating this chamber under either positive or negative pressure as required. The water finally discharges through a sluice gate at the bottom of the vacuum chamber, or may be allowed to enter the chamber above the vacuum chamber from which a flume carries it to a sharp-crested weir.

Because of the wide range required in tailwater elevation, it was impractical to use a weir regularly for measuring the laboratory discharge. A 36 x 15-in. Venturi meter was installed in the main penstock for measuring the water flow; connections to this Venturi meter were brought into the laboratory so that the discharge may be measured in the main laboratory.

Power developed by the test turbine is absorbed by an electric dynamometer mounted on the laboratory floor above the pressure chamber, rated at 300 hp when used as a generator, but also designed to develop 225 hp for operation as a motor for proposed pump tests. This dynamometer was designed specially for this installation and is the first one ever made for vertical mounting. Electrical output from the dynamometer is dissipated in grid resistors.

To facilitate the study of cavitation, the laboratory was laid out to permit visual observation of the water flowing in the draft tube just below the model runner. This has been accomplished by installing small glass windows in the tube. A chamber around the draft tube affords a point of observation for watching the formation of cavitation and the general behavior of water in the vicinity of the runner.

## Cavitation Limit of a Turbine

As previously stated it is of utmost importance to place the turbine runner at the proper elevation with respect to the tailwater surface. If any type of waterwheel is too high above the tailrace, the vacuum formed under the runner blades may cause cavitation, which can result, in addition to a serious loss of efficiency, in the destruction of the runner and draft tube by pitting. Pitting is probably due to a combination of erosive and corrosive action.

Cavitation starts when the absolute pressure at any point in the water column approaches the vapor pressure of the water, which pressure is, of course, very near absolute vacuum. In propeller turbines the velocity of the water is maximum and consequently the pressure minimum where the water passes through the runner. The exact location of minimum pressure depends upon the runner design. If this low pressure is below the vapor pressure at any point along the blade surface, the water will have a tendency to leave the surface of the blade forming a void; such voids will be filled quickly with a mixture of water vapor and air removed from the adjacent water by "cold boiling." The surface of separation between the flowing stream and the eddying region left by the separation may be shown theoretically to be essentially unstable; hence, sudden breakdowns of the cavities rapidly recur, having the effect of continuing explosions, resulting in intense hammer action in the pores of the metal. Eventually such action erodes the surface of the runner blades. In addition to this erosion it is probable that oxygen, which is released readily from solutions at very low pressures accumulates along the surface of the runner blades, and attacks the steel surfaces, especially where the metal has been attacked previously by erosion.

Cavitation can be practically eliminated by setting the runner sufficiently below the tailwater level to insure that the minimum pressures along the blade surfaces are well above the vapor pressure. For economic reasons it is important to determine accurately the maximum elevation at which the runner may be set so as to reduce to a minimum the expensive excavation work for the draft tube and tailrace.

Tests on a complete model of the Safe Harbor intake, scroll case, wheel setting, runner, and draft tube were made to determine within close limits the highest elevation at which the runner could be set without danger of serious cavitation for the maximum turbine power desired. Fig. 4 shows the results of a typical test made for determining the value of draft head at which cavitation starts. Efficiency, power, and discharge of the turbine have been plotted against a coefficient called Σ (sigma). The term Σ first introduced by Professor Thoma of Germany is derived as follows:

Theoretically cavitation starts when the absolute pressure on the runner is equal to the vapor pressure of water; therefore

$$H_B - H_D - \frac{\Sigma V^2}{2g} = H_v \qquad (1)$$

where

$H_B$ = Barometric pressure in feet of water at the surface of the tailwater

$H_D$ = Draft head (elevation of runner minus elevation of water surface in tailrace)

$\Sigma$ = Coefficient

$\frac{V^2}{2g}$ = Velocity head at the blade surface

$H_v$ = Vapor pressure of water

$\frac{V^2}{2g}$ varies directly with $H_T$, the total net head on the runner.

Therefore eq. 1 may be written

$$\Sigma = \frac{H_B - H_D - H_v}{H_T} \qquad (2)$$

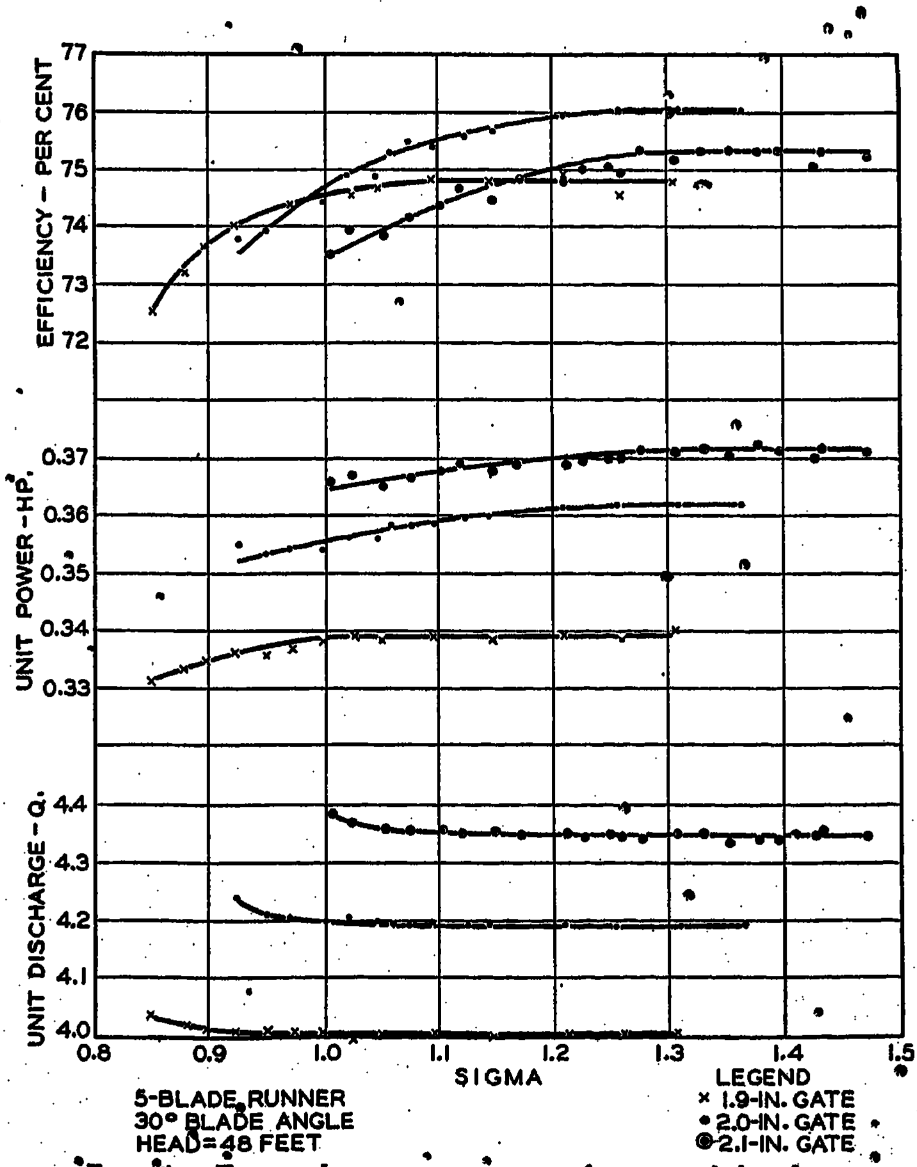


**Fig. 4. Typical cavitation curves for a model turbine**

Laboratory procedure in determining the cavitation limit for a definite blade angle and gate opening was to start with a high tailwater elevation and make a series of tests with gradually decreasing tailwater level maintaining for each series a constant total head and a constant speed. The value of Σ at which efficiency and discharge were found to break, was taken as the cavitation limit for that particular speed, head, and gate opening. Similar tests were made for each combination of head, gate opening, and blade angle. From the results it was possible to predict the cavitation limit of a model runner for various operating combinations of draft head and total head. From an operating standpoint it was essential to establish the limits of power output for a wide range in both draft head and total heads.

## Model Tests of Draft Tube Design

Correlated with the study of the cavitation limits of a turbine, and the economics of determining the proper runner elevation, is the problem of draft tube design. A draft tube with the shortest vertical section usually will be the least expensive, as minimum excavation will be required not only under the power house substructure but also in the tailrace below the power house. A review of European experience together with theoretical considerations of water velocities through a Kaplan runner led to a decision in favor of an elbow type of tube.

Each of the turbine manufacturers submitted alternate designs of elbow tubes, all of which were tested in the Holtwood laboratory with the Safe Harbor model runner, to obtain comparative data on the relative efficiencies and operating characteristics. These tubes differed in the following general features of design:

1. Angle of flare in the vertical section just below the runner.
2. Length of the vertical section (distance between centerline of runner and lowest point of the tube).
3. Location and area of the draft tube "throat."
4. Shape and angle of divergence near the discharge end of the horizontal section.

The final design chosen (see Fig. 5) was determined not only from a consideration of the maximum efficiencies obtained, but also with due regard to the shape of the horsepower-efficiency curves, in order to obtain a curve as flat as possible for each blade angle position, thereby eliminating any possibility of instability resulting from sudden changes in load. An appreciable amount of excavation was saved by turning the whole tube upward through an angle of 9°; it was found that this could be done without sacrificing either efficiency or power.

## MODEL TESTS OF SCROLL CASE DESIGN

A series of scroll case tests were made in the laboratory, before deciding upon the final design, to determine whether any advantage is realized by offsetting the center line of the runner shaft from the center line of the intake, thereby increasing the cross-sectional area of the scroll and reducing the velocity of the water. The results indicate that if for the unit spacing used at Safe Harbor, a speed ring with a relatively large diameter was used, a quite noticeable saving in efficiency and power could be obtained; if, however, the fixed guide vanes of the speed ring were of narrow proportions and the speed ring of smaller diameter, no improvement was found in either efficiency or power.

Scroll cases of the Safe Harbor turbines were designed eccentric, however, even though the speed rings were of relatively small diameter. This decision was made to permit maximum flexibility in the design of the wheel settings for all future units of the plant.

## POWER AND EFFICIENCY TESTS

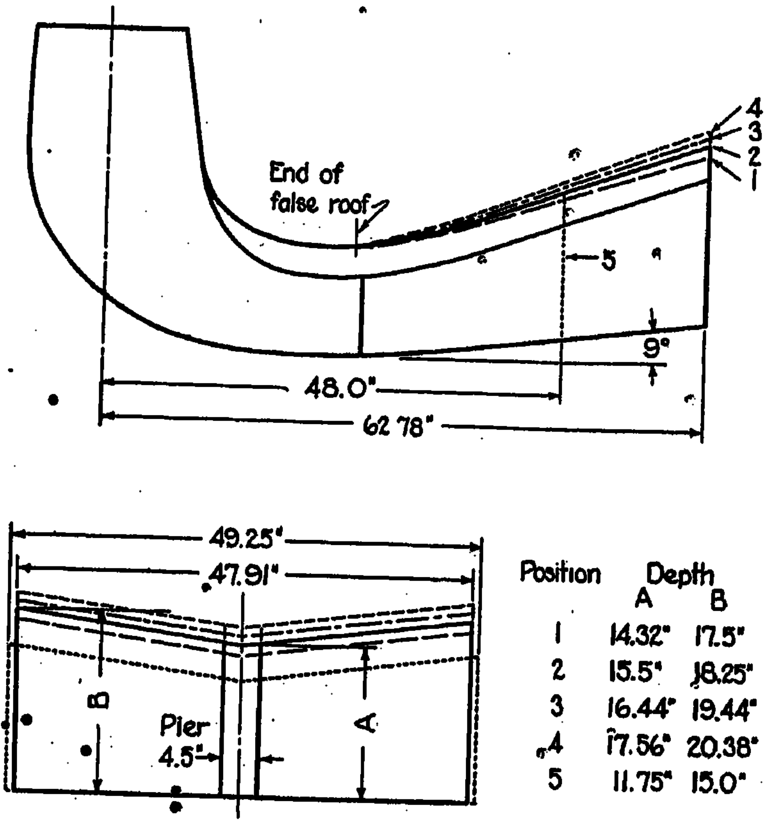
Comparative power and efficiency tests on each of the numerous turbine designs submitted were made at the Holtwood laboratory, all tests being made with a complete turbine setting, including intake, scroll case, and draft tube. These tests were made under a head approximately equal to the field head at Safe Harbor (about 50 to 55 ft) and in each case were conducted in the presence of a representative of the manufacturer whose runner was under test. At the completion of the tests the manufacturers were given the opportunity to revise their guarantees of power and efficiency on their respective turbines. Some of the guarantees for the final Safe Harbor units are shown in Fig. 6.

Curves giving the results of a typical test are shown in Fig. 7. The range in values of $\Phi$ covered corresponds to a variation in head of from 32 to 60 ft, although the actual testing was done under a constant head and varying speeds. Tests were made at various blade angles to obtain an envelope curve representing the maximum efficiency obtainable for the proper operating relationship between blade angle and wicket gates; as previously described this relationship is maintained on the actual units by means of a cam in the blade operating mechanism.

## FIELD TESTS

To insure that the units are properly adjusted and are operating to give the best possible efficiency, numerous field tests and inspections were planned. A small amount of cavitation probably is permissible since the steel blades of the turbine are quite shock-resistant; therefore it was decided to operate the units slightly beyond the point where cavitation started in the laboratory, and study carefully the effect on the runner blades and draft tube.

During the first few months of operation the turbines were inspected about every 2 weeks. Now that the plant has been in operation some time, these inspections are made about every 6 weeks on each unit. It has been found that on certain portions of the runner blades paint was removed. In addition a small area on both the top and bottom blade surfaces at the leading edge near the periphery seemed to be subject to local cavitation. Minute hollows and reversals in curvature attracted cavitation, and eventually pitting took place. However, by slightly reshaping the leading edge of the blade so that it was sharper, and making an exceedingly gradual transition from the nose to original blade surface from 6 to 8 in. back from the leading edge, this local cavitation was largely eliminated. This area probably always will be susceptible to cavitation, and consequently it is of the greatest importance to have a very smooth surface, free from reversals in curvature. One unit



| Position | Depth A | Depth B |
|---|---|---|
| 1 | 14.32" | 17.5" |
| 2 | 15.5" | 18.25" |
| 3 | 16.44" | 19.44" |
| 4 | 17.56" | 20.38" |
| 5 | 11.75" | 15.0" |

**Fig. 5. Various modifications of the Safe Harbor draft tubes studied at the Holtwood laboratory**

Dimensions are for the model tube

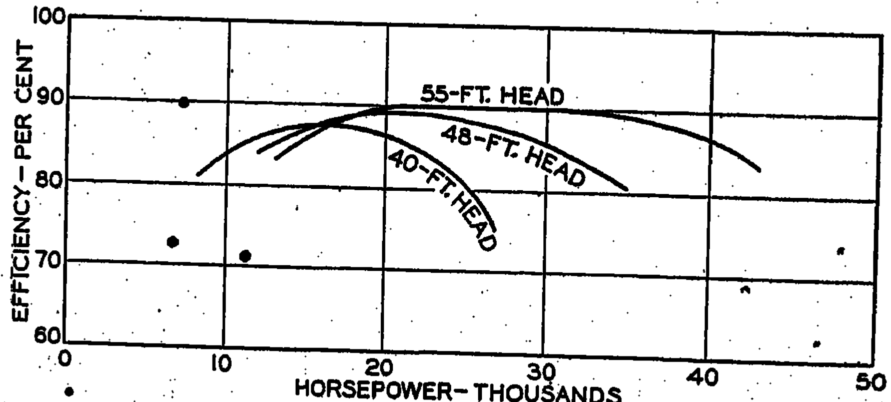


**Fig. 6. Guaranteed horsepower-efficiency curves for a Safe Harbor turbine running at rated speed of 109.1 rpm**

was held at a power output limit well below the point where cavitation started on the model. The paint erosion on this unit was less than on the other units, but the local pitting was of about the same magnitude, and in the same place.

On the underside of the blades near the trailing edge, an area has been attacked by slight cavitation of a magnitude sufficient to remove the paint, but as yet there is no indication of pitting. It is interesting to note that rust has covered these areas in spite of the cavitation.

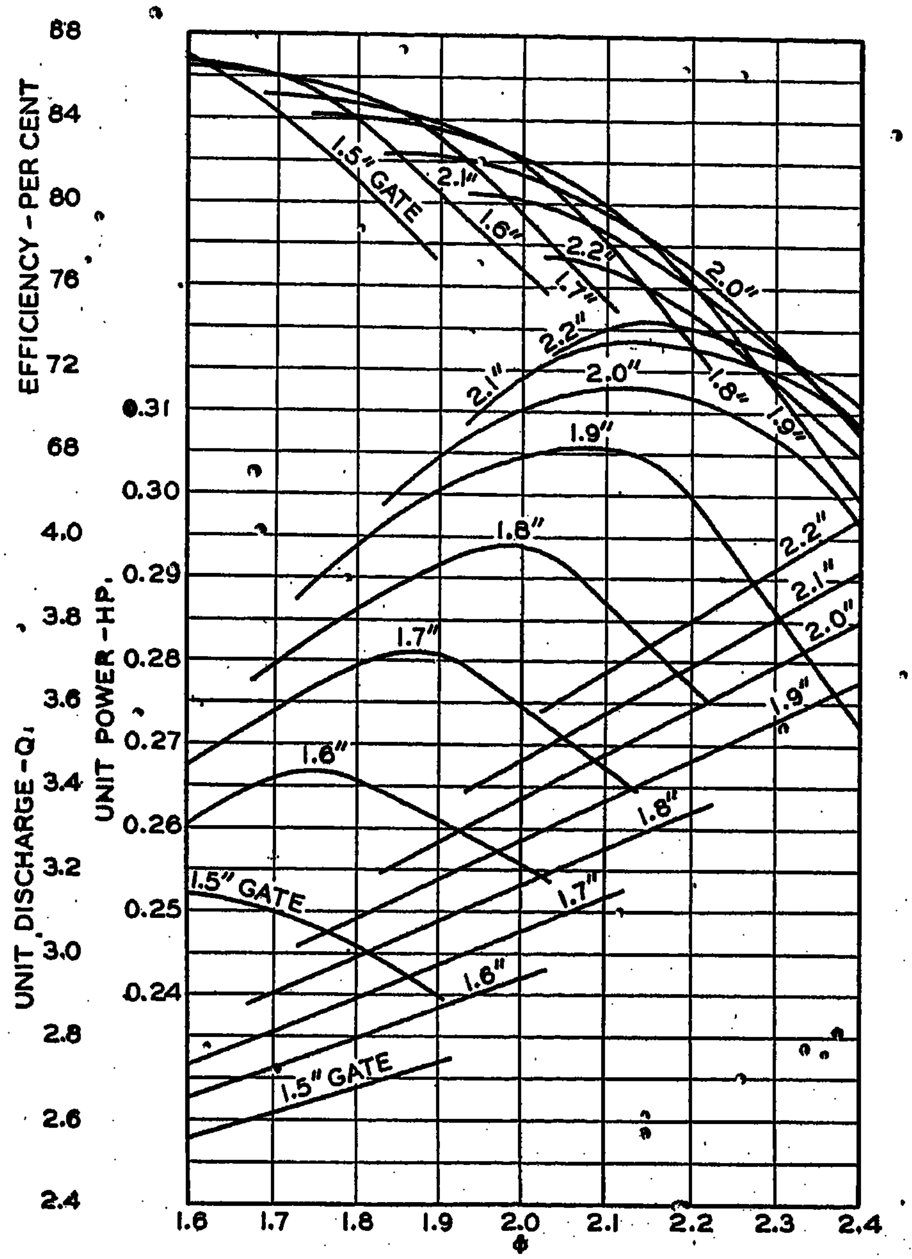


**Fig. 7. Typical efficiency curves computed from test results on a model turbine; blade angle 22°**

Φ is the ratio between peripheral speed of the runner and spouting velocity for the head in question

To establish the most efficient relationship between gate opening and blade angle, it is not necessary to measure the actual efficiency or discharge; it was decided to establish this relationship by the use of an index method. At various points in the scroll case and on the wheel setting 7 piezometers were installed during the construction of the plant. At the time of the turbine efficiency tests these piezometers will be calibrated and a meter ultimately will be installed to integrate as well as indicate the discharge through the turbines. It is proposed to have a meter on each unit. A totalizing meter will be installed in the control room to indicate the total discharge through the plant.

Methods of testing hydroelectric units commonly used in this country have been found inadequate on most low head developments where large quantities of water are to be measured, because of the shortness of the approach passages to the unit. In Europe, current meters have been used for many years in making efficiency tests, and have been found particularly well adapted for use on low head developments. Several turbine efficiency tests have been made in this country with current meters, but on such tests only a few meters were employed; the results usually have been of doubtful accuracy. It was decided at Safe Harbor to follow the European method of making current meter tests and to employ the Ott meter so generally used abroad.

One difficulty encountered in making current meter measurements is the time required to traverse the area of the metering section properly. It was found that a great many metering points would be necessary for each horizontal traverse. Therefore 27 current meters of the spoked-wheel type were purchased; these were mounted in the same horizontal plane on a rack made of stream line rods. This rack can be lowered in the gate slots to any desired elevation for obtaining a vertical traverse.

It was recognized that the Ott spoked-wheel current meter consistently under-registers for angular flow. The metering section at the gate slots is just at the end of the bell-mouth so that there obviously would be considerable angular flow near the top of the metering section. To obtain accurate measurements in that area, 27 conical screw propeller current meters were purchased and mounted on the same current meter rack 6 ft above the spoked-wheel meters. It was found that the difference between the indicated velocities of these 2 types of meters increased uniformly with an increase in the angle of flow; thus for a given difference in observed velocity on the 2 types of meters the true angle of flow could be determined readily and a proper correction could be applied to obtain the true velocities passing the metering section.

## CONCLUSIONS

The test program conducted in coordination with the plant design has resulted in numerous improvements in operating performance, has effected savings in construction costs, and has permitted a more complete study of the behavior of the Safe Harbor units. Such a program eliminated to a large degree the necessity of relying too greatly upon the limited field experience available. No little part of the success of this program depended on the close cooperation of the engineers of the 2 turbine manufacturers who for the first time in hydroelectric development in America, jointly developed and manufactured turbines of identical design wherein practically all replaceable parts are interchangeable.

The first 6 months of actual performance indicates that the prediction of the cavitation limits for the turbines based upon the laboratory model test results are reasonably close, although a longer period will be necessary to establish *definitely* a close correlation between laboratory and field results.

# News
## Of Institute and Related Activities

# Vancouver Convention Upholds Coast Reputation

AS THE OCCASION of his first formal public appearance as president of the A.I.E.E., H. P. Charlesworth opened the 21st Pacific Coast convention of the Institute at the Hotel Vancouver, Vancouver, B. C., Tuesday morning, August 30, 1932.

Preceding Mr. Charlesworth was Mr. W. G. Murrin, president of the British Columbia Electric Railway Company, Ltd., who was introduced by the convention chairman, G. R. Wright. Mr. Murrin stressed the great value and importance to human welfare of the free and wide interchange of technical knowledge concerning the practical application of the fruits of scientific research, regardless of international or selfish boundaries. Of the 3 common media of such exchange—direct correspondence, the technical press, and the personal contacts and discussions possible only through conventions and technical meetings—the speaker urged increasingly serious attention to the latter.

In his brief response of appreciation for the official welcome, Mr. Charlesworth referred to the remarkably rapid advances that have been made in science and engineering expressing the belief that further progress is inevitable. Citing from the broad field of electrical engineering such examples as the modern facilities in transportation by land, sea, and air; in communication by wire and by radio; and in the applications of electric power devices that constantly are reducing the drudgery of factory, office, and home, the speaker pointed out that all of these must of necessity have a profound effect upon our daily life. In consequence, engineers, individually and collectively were pointed out as having in addition to obvious technical duties, a very real and human responsibility in sociological matters ranging all the way from local civic interest to national government.

A pleasant surprise to all, and a fitting tribute to the unremitting year-long efforts of the committees in charge, was the attendance of 300 persons. Every Section in the far-western Districts was represented as were also 13 out of the 14 Student Branches. In addition to President Charlesworth, Institute officers present included vice-presidents A. W. Copley of San Francisco, Calif., C. R. Higson of Salt Lake City, Utah, and L. B. Chubbuck of Hamilton, Ont., Canada. The attendance is analyzed in an accompanying tabulation.

Technical Sessions

The technical sessions featured the 14 papers listed on p. 519 of Electrical Engineering for July 1932, each paper drawing its share of discussion. They were divided among 4 sessions devoted in general to power generation; transportation, electrical machinery, and metering; station apparatus; and communication and power transmission. Presiding over these meetings, respectively, were A. W. Copley, H. V. Carpenter (past vice-president), L. B. Chubbuck, and C. R. Higson.

Table I—Analysis of Attendance at 1932 Pacific Coast Convention

| Classification | Location<br>Vancouver | <br>Dist. No. 9 | <br>Dist. No. 8 | <br>Misc. | Totals |
|---|---|---|---|---|---|
| Members | 66 | 41 | 21 | 7 | 135 |
| Men Guests | 59 | 4 | 2 | 1 | 66 |
| Women Guests | 28 | 16 | 12 | 3 | 59 |
| Students | 16 | 11 | 10 | 3 | 40 |
| Totals | 169 | 72 | 45 | 14 | 300 |

In addition to the foregoing, 2 student sessions were held, one with the gavel in the hand of F. C. Carmen, chairman of the University of Utah Branch, and the other under the direction of W. D. Hudgins, chairman of the University of California (Berkeley) Branch. At these sessions the following papers were presented:

Electrical Properties of Hardened Copper, A. J. Hill and Homer Lambkin, Montana State College.

Steam Versus Electric Drive for Sawmill Operation, E. A. Buckhorn, Oregon State College.

Electrical Reflections in A-C Machinery, D. J. Moore, University of Washington.

Comparison of Two Methods of Calculating a Transmission Line, Duane Olney and N. A. Miyota, Washington State College.

Effect of Atmospheric Conditions on Corona Loss, Victor Siegfried, Stanford University.

Short Circuit and Arcing Characteristics of Renewable Link Cartridge Fuses, Louis Beyha and Oliver Jesson, University of Southern California.

A Stroboscopic Device for Studying Rotary Motion, Kenneth Nielsen and W. S. Nishiyama, University of Utah.

Investigation and Application of the Ultra-Short Waves in Radio, J. H. Russell and J. A. O'Neil, University of Santa Clara.

The Parallel Type Inverter, Wilson McRae, University of British Columbia.

A Timing Instrument for Transients, Suitable for Measuring Time Lag of Spark-Over, Abe. Tilles, University of California.

The Design of an Efficient Amplifier Coupled to an Antenna, Sydney Sillitoe, University of Alberta. Read by H. Freedman, University of British Columbia.

Attendance at all technical sessions averaged by actual count well in excess of 100. The delegates and guests were invited to a special luncheon meeting of the Vancouver Electric Club to hear the address of Capt. E. A. Wheatley, registrar of the British Columbia Association of Professional Engineers, concerning the importance to engineers of their cooperating effectively in the control and application of engineering education.

Student Activities

In addition to the technical sessions already mentioned the Enrolled Students and their Counselors were the feature participants in a luncheon meeting held Tuesday, August 30, and a dinner at the University of British Columbia immediately preceding the annual student conference held there at 8 p.m., September 2, with Dr. J. H. Hamilton, counselor, University of Utah Branch, presiding. The meeting was opened by brief addresses by President H. P. Charlesworth and Vice-President A. W. Copley of the Pacific District, both of whom emphasized the importance of student activities in the further development of the Institute.

Of the 14 Branches in Districts 8, 9, and 10, eight were represented by their counselors and chairmen, and each of the others was represented by either the counselor or the chairman. Branch counselors present included: J. C. Clark, Univ. of Arizona; R. W. Sorensen, Calif. Inst. of Tech.; L. E. Reukema, Univ. of Calif.; N. C. Clark, Univ. of So. Calif.; J. H. Johnson, Univ. of Idaho; J. A. Thaler, Montana State Col.; E. C. Starr, Oregon State Col.; J. H. Hamilton, Univ. of Utah; O. E. Osburn, State Col. of Wash.; G. R. Shuck, Univ. of Wash.; and E. G. Cullwick, Univ. of British Columbia.

The Branch chairmen present included: Bruce Watkins, Univ. of Arizona; M. S. Hodge, Calif. Inst. of Tech.; W. D. Hudgins, Univ. of Calif.; J. H. Russell, Univ. of Santa Clara; R. R. Moore, Univ. of So. Calif.; G. W. Dunlap, Stanford Univ.; R. S. Stokan, Montana State Col.; R. J. Mather, Oregon State Col.; F. C. Carmen, Univ. of Utah; and P. W. Hand, State Col. of Wash.

Some of the topics of discussion were the desirability of the selection of the dates of future Pacific Coast conventions in order to secure Labor Day railroad rates, traveling expenses allowed for the conferences on student activities, and methods of providing for closer cooperation between the University of British Columbia Branch and the Branches in the North West District. The vice-presidents of the Pacific and North West Districts were requested to appoint a joint committee to consider these matters and prepare recommendations.

Much interest was exhibited in the student technical papers presented at the convention, and there was a discussion regarding the mimeographing, and advance distribution of the papers prepared for future conventions.

### Entertainment

The social program, delightful in its simplicity and satisfying in its variety, was opened formally by the reception for President Charlesworth, with a subsequent dance held Tuesday evening. Women's events included trips to various points of interest, an afternoon's outing in Vancouver's famous Stanly Park featured by tea and a pitch-and-putt golf tournament, and a bridge tea held Friday afternoon. Winners of golf prizes were Mrs. C. Arnott of Vancouver, B. C., and Mrs. H. O. Blair of Tacoma, Wash.; Mrs. H. V. Carpenter of Pullman, Wash., won a special prize for making a hole-in-one on her initial round.

A 4-hour boat trip with dinner served aboard drew 188 men and women out Wednesday evening in spite of rainy weather. The trip was made on the Canadian Pacific steamer "Princess Norah." The convention dinner held Thursday evening also proved to be an attractive affair, there being some 240 persons in attendance. President Charlesworth in addressing the banqueters briefly recalled one of the principal motives of the Institute as being "the advancement of the theory and practise of electrical engineering and its allied arts and sciences, the maintenance of a high professional standing among its members, and the development of the individual engineer." In this connection he emphasized how well the Institute's conventions in general and the Vancouver convention in particular functioned to maintain this underlying principle of development regardless of political boundaries. In part he said: "We are indeed advancing effectively the theory and practise of electrical engineering through the interchange of information . . .; also we are aiding the professional standing and development of our individual engineers. . . . Not only professionally but also personally do we gain from these meetings."

Concerning the much talked of matter of the engineer's place in our general social-economic structure, Mr. Charlesworth said in part: " . . . . Whether we are concerned with research, engineering, education, or any other branch of the profession, it is evident . . . . that we cannot but be called upon to play an even greater part in the problems attendant upon the application of the results of our work, and, in fact, in the general affairs of society. If we recognize these opportunities, and individually and collectively do our full share, and if we fully appreciate that we cannot approach these problems alone as engineers, but rather collectively with all other groups of society, we shall not only make a real contribution to the solution of some of the difficult problems now confronting our individual countries and the world in general, but we shall have enhanced materially the prestige of our profession."

Following Mr. Charlesworth's address the amateur dramatic club of the British Columbia Electric Railway Company cleverly enacted a little skit entitled "The Mayor and the Manicure." Prizes for Institute papers as announced on p. 418 of Electrical Engineering for June 1932, were presented by President Charlesworth; the presentation of golf prizes brought the evening's affair to a close.

Other activities for men included sight-seeing and several splendid inspection trips, the most popular one being the trip to the new Ruskin hydroelectric plant of the British Columbia Power Corporation. The annual golf tournament drew 54 registrants from among the golfers and the near-golfers. With the play at the Shaughnessy Heights Golf Club the aspirants were treated to a course not especially sporty, but replete with long holes and strategically located traps in great profusion. The Fisken Cup, prized Pacific Coast trophy named for John B. Fisken of Spokane, Wash., was won by J. E. Underhill (A'29) of Vancouver, B. C., score: 98 − 30 = 68 net. Mr. Underhill stated that he was as astonished as were his competitors; he never before had broken 100. Other winners were: Prof. E. G. Cullwick (A'26), G. K. Haspal (M'31), J. A. Tames (A'27), and S. Anderson of Vancouver; G. I. Wright (M'28) of Philadelphia, Pa., low gross (88); C. R. Higson (M'32) and Prof. J. H. Hamilton (A'28) of

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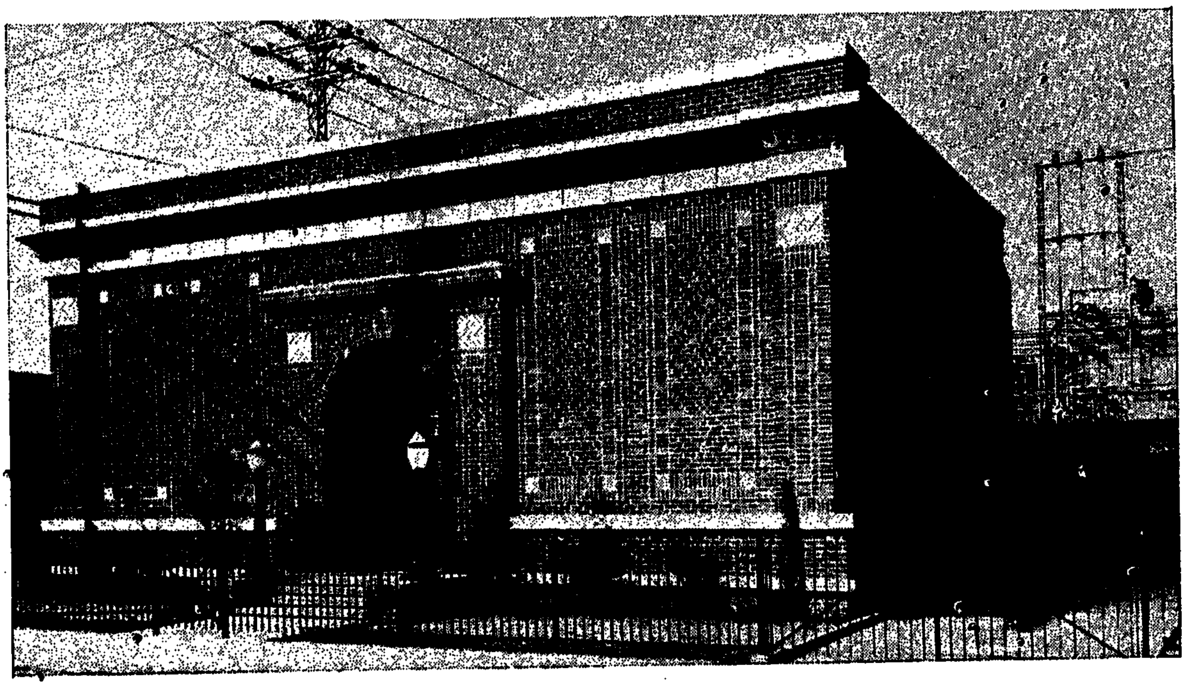
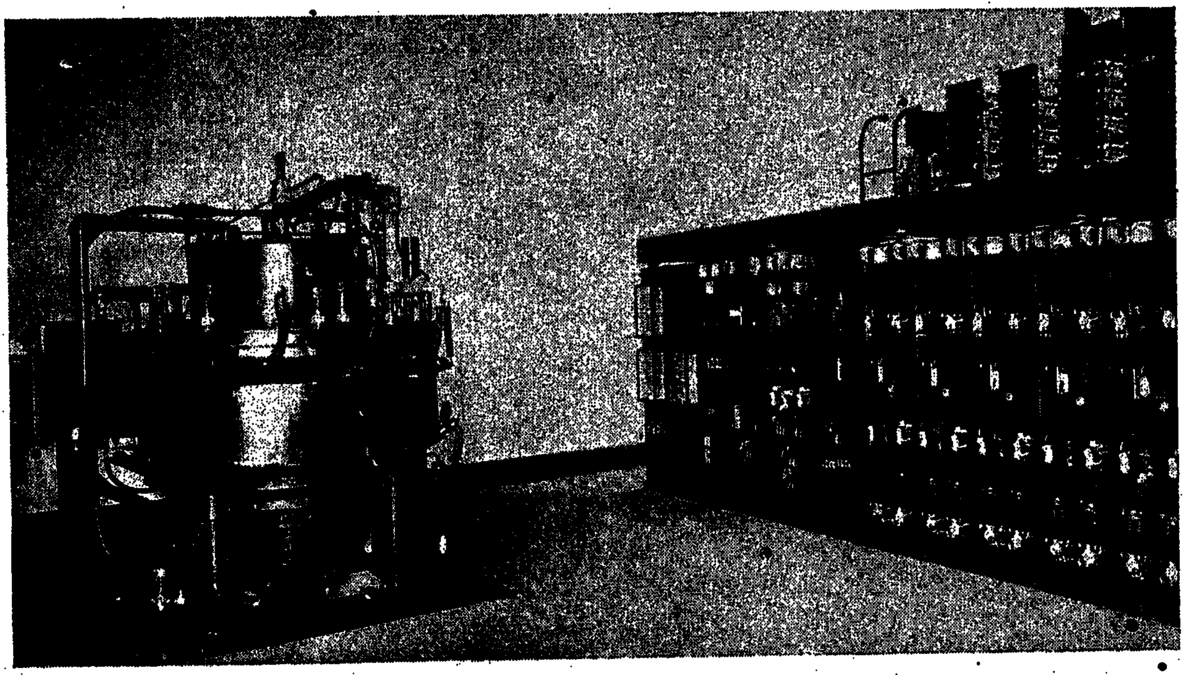
# Mercury Arc Rectifier Substation of Pleasing Design





Two additional mercury arc rectifiers, each of 1,500-kw. capacity, have been placed in service by the Los Angeles Railway Corporation in its new Slauson substation. The rectifiers are provided with complete automatic control. Both the exterior and interior designs of this substation are deserving of attention. Architectural features to harmonize well with other buildings in a residential district are incorporated in the building. One continuous switchboard provides the control for the 2 General Electric rectifiers, 4 a-c 16,500-volt incoming lines, 4 a-c tie breakers, 4 power transformers each rated 1,500 kva 16,500–935 volts, and 12 d-c feeders each rated 600 volts, 1,200 amp. This control board is particularly interesting in that it provides automatic, supervisory, and manual control—whichever may be desired.

Salt Lake City, Utah; J. I. Little (A'22), Prince Rupert, B. C. (158). Successful in estimating themselves into the kickers hat and lucky in having their names drawn therefrom were Joseph Hellenthal (M'23) of Seattle, Wash.; C. F. Norburg (A'28) of Spokane, Wash., and M. Legge of North Vancouver, B. C.

## District Meeting at Baltimore Impends

Shortly after this issue of Electrical Engineering goes to press the Institute's Middle Eastern District meeting will be held in Baltimore, Md., October 10–13, 1932, with headquarters in the Lord Baltimore Hotel. A report of this meeting is scheduled for the November issue, and a summary of the discussions on the Baltimore meeting papers will be presented as soon as they are made available by the discussers. To be considered for publication discussions should be written and mailed to the A.I.E.E., editorial department, 33 West 39th Street, New York, N. Y., on or before October 28, 1932.

The program of the Baltimore District meeting was announced in Electrical Engineering for September 1932, p. 663–4, and abstracts of all papers then scheduled for presentation at the meeting were also given in the September issue, p. 659–62.

## Institute Affairs Discussed at Vancouver Convention

A luncheon of Institute, District, and Section executives, and Student Counselors, was held in the Italian room of the Hotel Vancouver on August 31, 1932, in connection with the Institute's recent Pacific Coast convention at Vancouver, B. C. C. R. Higson (vice-president District 9) acted as chairman of the meeting, and after congratulating the local convention committee on their arrangements for this convention, briefly discussed the 1934 Pacific Coast convention. He called attention to the fact that the board of directors of the Institute had approved the recommendation made during the 1931 convention that the 1933 convention be held at Salt Lake City, Utah. The local members under the leadership of B. C. J. Wheatlake have begun their plans for the convention.

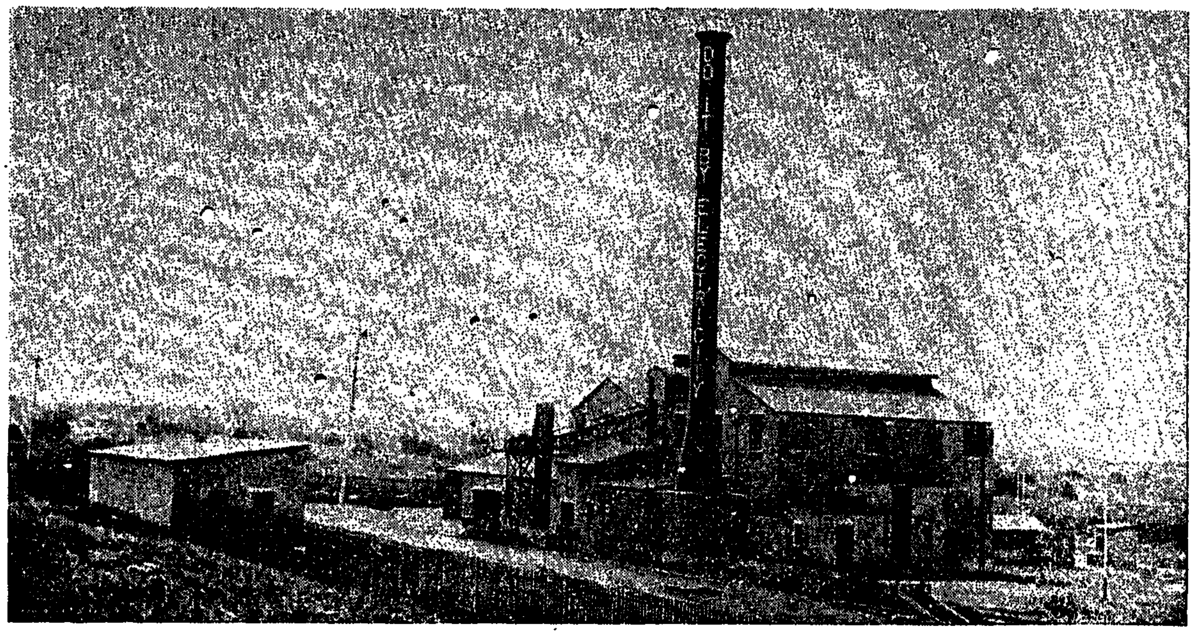
A. W. Copley (vice-president District 8) San Francisco, Calif., stated that the board of directors will decide in January 1933, the location of the 1934 Pacific Coast convention, and moved that this meeting recommend to the directors that the 1934 convention be held under the auspices of the Los Angeles Section. This motion was carried unanimously.

Pres. H. P. Charlesworth offered his congratulations to those responsible for the technical and student sessions and the entertainment features, commenting specifically on the featuring of student activities. He also said that Dr. Frank B. Jewett (past-president) had reminded him that the German electrical engineers this year are celebrating the sixtieth birthday of Dr. Carl Von Siemens, and had suggested that the convention send a congratulatory cablegram to Doctor Siemens. It was moved, seconded, and unanimously carried that H. H. Henline, acting national secretary, be requested to send this cablegram.

The publication in Electrical Engineering of papers not published in the Transactions was discussed, and a motion was carried that Electrical Engineering be requested to publish the paper "Metering of Symmetrical Components" by G. R. Shuck, which the technical program committee had recommended be not published by the Institute.

After further discussion of the value of Student sessions and the recommendation that close cooperation between Student Branches and Sections is highly desirable, the meeting adjourned.

## A Power Plant in Central Africa



A MODERN power plant differing considerably from those found in the United States is illustrated above. It is owned by the Ndola Electricity Undertaking, Ndola, Northern Rhodesia, Africa, and is located in the heart of the Northern Rhodesian copper belt. The photograph was supplied by D. W. V. Ellis (M'32), manager and engineer, Ndola Electricity & Water Undertakings.

## Nomination of 1933 Institute Officers

Actions specified in the Institute's constitution and bylaws relative to the organization of a national nominating committee are being taken, and the meeting of the national nominating committee for the nomination of officers to be voted upon at the election in the Spring of 1933 will be held between November 15 and December 15, 1932. All suggestions for the consideration of the national nominating committee must be received by the secretary of the committee at Institute headquarters, New York, N. Y., not later than November 15, 1932.

The sections of the constitution and bylaws governing these matters are quoted below:

**Constitution**

28. There shall be constituted each year a national nominating committee consisting of one representative of each geographical district, elected by its executive committee, and other members chosen by and from the board of directors not exceeding in number the number of geographical districts; all to be selected when and as provided in the bylaws; the national secretary of the Institute shall be the secretary of the national nominating committee, without voting power.

29. The executive committee of each geographical district shall act as a nominating committee of the candidate for election as vice-president of that district, or for filling a vacancy in such office for an unexpired term, whenever a vacancy occurs.

30. The national nominating committee shall receive such suggestions and proposals as any member or group of members may desire to offer, such suggestions being sent to the secretary of the committee.

The national nominating committee shall name on or before December 15 of each year, one or more candidates for president, national treasurer, and the proper number of directors and shall include in its ticket such candidates for vice-presidents as have been named by the nominating committees of the respective geographical districts, if received by the national nominating committee when and as provided in the bylaws; otherwise the national nominating committee shall nominate one or more candidates for vice-president(s) from the district(s) concerned.

**Bylaws**

Sec. 22. During September of each year, the secretary of the national nominating committee shall notify the chairman of the executive committee of each geographical district that by November 1 of that year the executive committee of each district must select a member of that district to serve as a member of the national nominating committee and shall, by November 1, notify the secretary of the national nominating committee of the name of the member selected.

During September of each year, the secretary of the national nominating committee shall notify the chairman of the executive committee of each geographical district in which there is or will be during the year a vacancy in the office of vice-president, that by November 15 of that year a nomination for a vice-president from that district, made by the district executive committee, must be in the hands of the secretary of the national nominating committee.

Between October 1 and November 15 of each year, the board of directors shall choose 5 of its members to serve on the national nominating committee and shall notify the secretary of that committee of the names so selected, and shall also notify the 5 members selected.

The secretary of the national nominating committee shall give the 15 members so selected not less than 10 days' notice of the first meeting of the committee, which shall be held not later than December 15. At this meeting, the committee shall elect a chairman and shall proceed to make up a ticket of nominees for the offices to be filled at the next election. All suggestions to be considered by the national nominating committee must be received by the secretary of the committee by November 15. The nominations as made by the national nominating committee shall be published in the January issue of ELECTRICAL ENGINEERING, or otherwise mailed to the Institute membership during the month of January.

(*Signed*) H. H. HENLINE,
October 1, 1932. *Acting National Secretary*

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# Summarized Review of Some Pacific Coast Convention Discussions

PRINCIPAL discussions of the Pacific Coast convention papers are summarized herewith. The papers to which these discussions refer were abstracted in ELECTRICAL ENGINEERING for August 1932, p. 583–6.

Only discussion submitted in writing in accordance with governing A.I.E.E. rules is summarized. Complete discussion, together with all approved papers, will be published in the TRANSACTIONS.

### READING COMPANY'S PHILADELPHIA SUBURBAN ELECTRIFICATION

A. J. Schoch (Philadelphia, Pa.) discussed this subject and corroborated the attainments brought out in the paper as a result of electrification. He called attention to the simplicity and ease of erection and maintenance of the 2-wire catenary system which experience has shown results in a quality of current collection better than that obtained from the usual compound catenary systems. He referred also to the improvements made in the car equipment. Aluminum alloys were used in the non-stress carrying members, and by a careful location and arrangement of equipment underneath the car, the original installation was not only simplified but the job of inspecting and maintaining the equipment was made much easier.

### ELECTRICAL OPERATION ON THE GREAT NORTHERN RAILWAY

W. F. Coors (Tacoma, Wash.) discussed in connection with this subject several troubles encountered on the electrical equipment of the Milwaukee Road which were due to unexpected moisture conditions affecting insulation. One of these troubles occurred when under certain weather conditions the depression in the top of the traction motor frame housings for recessing the field pole capscrew heads filled with snow. Later when the traction motors warmed up at work, the snow would melt and the resulting water ran through the bolt holes into the traction motor cases, usually causing field coil insulation failures. This trouble was prevented by filling the recesses with battery sealing compound.

G. H. Walker (Seattle, Wash.) briefly but interestingly outlined the electric system of this electrification and the terms for purchasing power which include an increase in the demand charge when 13,000 kw is exceeded. It is of interest to note the method by which this demand is limited. This was accomplished by equipping each locomotive unit with an indicating ammeter visible to the engineman and connected in the circuit to the synchronous motor of the motor generator set. Tests were conducted to determine the demand for various readings on the ammeter for each type of locomotive unit. The results were tabulated and given to the train dispatchers who in turn when dispatching trains assign a load limit to each locomotive unit on the line for any given period of time. This the dispatcher does by giving orders to the engineman not to exceed so many amperes between certain locations or at certain times. This method of power limitation has been used without undue handicap to schedules and it has resulted in a considerable saving in power costs. The discussion was supplemented with data on power consumption and traffic, together with a reproduction of an actual train sheet and load diagram.

Another discussion on this subject by R. T. Strong (Seattle, Wash.) drew attention to the distinction that must be made between the terms "locomotive unit" and "locomotive." The latter term designates one or more locomotive units operating together. Mr. Strong then illustrated the importance of selecting locomotive unit sizes so as to obtain the greatest flexibility combined with maximum standardization. It also was illustrated with data given in the paper and from the history of most railway electrifications that train weights originally specified by the railways rarely have been adhered to. The discusser believes that electrical engineers laying out a new railway electrification should keep this tendency in mind and leave an ample margin in the design for increases in train weight. In connection with the condensation difficulties described in the paper, Mr. Strong explained 2 additional causes contributing to high temperatures in the tunnel. These were the presence of warm springs within the tunnel and the heat thrown off by the chemical action of the setting of newly poured concrete. He believes that difficulties with the locomotives are due entirely to condensation within the cabs, and not to snow or water drawn in from the outside.

### CORONA LOSS MEASUREMENTS

In connection with this subject W. S. Peterson (Los Angeles, Calif.) presented and analyzed a theoretical formula modified by empirical correction to fill the need for some method of calculating corona loss for the lower values of losses as well as the higher values. In the development of the formula the corona loss was considered to be that due to charging current flowing radially through the corona envelope. The drop in voltage through the envelope was assumed as being the integral of the potential gradient from the point where the gradient in air exceeded 53.6 kv per in. effective values, to a point on the conductor at some higher value. Instantaneous values of current and voltage were used, and for the portions of the cycle at which the voltage is too low to cause air breakdown, no loss was assumed to occur. The discusser explained that the formula evolved from this theory and further empirical corrections had served quite well to give accurate curves for practical engineering purposes. Excellent agreement also has been obtained with a great variety of tests.

### TRIPLE HARMONIC EQUIVALENT CIRCUIT IN 3-PHASE POWER TRANSFORMER BANKS

P. W. Blye (New York, N. Y.) in discussion of this subject cited his experience with tests on transformers similar to those made by the authors. These tests corroborated their general conclusion that at a given excitation or over a narrow range of excitation, the equivalent $T$ network described in the paper presents a simple and accurate method of dealing with triple harmonics arising in 2-winding transformers. However, the discusser did not agree with several points brought out in the paper incidental to the general conclusions. For example, the statement in the paper that the total leakage impedance as measured by the usual short-circuit method was found to be considerably in error as compared to the sum of the individual leakage impedances used in the equivalent circuit and observed at normal excitation by the delta-opened-delta method. He also recalled certain cases where the leakage impedance associated with one winding of a 2-winding transformer actually had been found to increase slightly with increasing excitation.

A. Boyajian (Pittsfield, Mass.) in his discussion of this subject referred to the application of a single equivalent circuit for bank No. 3 in Fig. 6 of the paper. He explained that this circuit was not applicable both for the currents produced by $E_3$ and for those produced by $E_2$. He believed that a single equivalent circuit to satisfy these conditions would have to be of the 6-link type which is very difficult to construct and use. It was felt that the good results claimed by the authors with the use of a single 3-link equivalent circuit seemed to imply that in the case under consideration the 2 equivalent circuits did not happen to differ materially from one another.

Another discussion by H. V. Carpenter (Pullman, Wash.) considered the magnetic conditions existing during the tests; it was explained that if 3 single-phase transformers were used, each phase would have its own independent magnetic core; if one type of

3-phase transformer were used, the 3 flux paths would be partially but not wholly independent; while if the other type were used, any flux passing through one core must return through the other 2. In this latter case the third harmonic flux would find no return path; so it would seem likely that the 3 different conditions would give somewhat different results.

D. I. Cone (San Francisco, Cal.) discussed this subject and it is his belief that despite the number of published articles, there still is need for the presentation of methods for quantitative prediction of the behavior of given networks. He believed this paper is a helpful contribution toward filling that need. In reference to Fig. 16 he felt that it was most encouraging to observe that even at the resonance point, it was practicable to predict the approximate magnitude of the third harmonic current. In conclusion, he suggested as a desirable extension of this study, others that would concern the distribution of triple harmonics in 3-winding transformers and associated lines.

E. G. Cullwick (Vancouver, B. C.) in his discussion of this paper questioned the authors' statement that the harmonics in the exciting current of a transformer are produced by voltages of like frequency produced in the transformer itself, due to the action of the steel core. He explained that due to the varying reluctance of the iron core, the magnetizing current necessary to produce the flux would not be sinusoidal, but would contain strong third and higher odd harmonics. To represent these harmonics in an equivalent circuit, it is logical to replace the varying impedance of the transformer by a constant impedance and a generator of odd harmonics, but the discusser did not believe it was accurate to state that the harmonics were actually due to electromotive forces generated in the transformer windings.

### SEGREGATION OF HYDROELECTRIC POWER COSTS

J. S. Moulton (San Francisco, Cal.) discussed this subject in regard to the conclusions in the paper that assuming that a plant could be constructed to operate at 100 per cent load factor, the base cost per kilowatthour would be the energy cost of service, and that the additional cost incurred by reason of less than 100 per cent load factor operation would be the demand cost of service. The discusser felt that the first of these conclusions was in reality a premise upon which the validity of much of the balance of the paper depended. He pointed out that it is equally correct to assume that the costs involved can be expressed upon a per kilowatt basis. The desirability of considering base costs as demand costs of service rather than an energy cost of service is illustrated by Fig. 7 of the paper and shows that with a fixed generating capacity installed, if the average kilowatts fall below 100 per cent load factor, the cost per kilowatthour increases. From a rate making standpoint, if the output of such a plant is sold upon a kilowatthour basis and upon the assumption that the plant will operate at 100 per cent load factor, and conditions change so that it operates at less than this load factor, it is obvious that at the fixed price per kilowatthour the total plant costs will not be met. On the other hand if the capacity is sold upon a kilowatt basis, then the total plant costs will continue to be met regardless of how the load factor may vary.

### FACTORY ASSEMBLIES FOR SUBSTATION DESIGN

J. S. Moulton (San Francisco, Cal.) discussed this subject also and reported that the average life of transmission switchboards in place on a certain system was 14.4 years. The average life for distribution switchboards was 13.2 years. The transmission switchboard account included high voltage oil circuit breakers, disconnecting switches, switch structures and miscellaneous appurtenant equipment. The distribution account included oil circuit breakers of an operating voltage of 11 kv or below, and otherwise was similar to the transmission account. As most of the equipment was relocated and some of it was moved several times during its life, the discusser suggested that serious study should be given to ways of increasing the capacity of existing apparatus so as to eliminate relocation if not abandonment. Study also should be given to ways of reducing the amount of installation labor, which must be written off in the case of a change in location.

## Section Activities for Fiscal Year Summarized

As part of an effort to distribute as widely as possible the benefits of affiliation with the Institute, a plan was formulated in 1902 to organize local groups of Institute members in electrical centers. Since that time the activities of these Sections have expanded very rapidly, and with the formation of a Montana Section authorized by the Institute's board of directors on June 24, 1931, the number of Sections was brought up to 60. Approximately 80 per cent of all Institute members now are within Section territory.

Section activities for the fiscal year ending April 30, 1932, were normal, and programs included a wide variety of interesting and important subjects. Despite the unfavorable business conditions, the number of applications for admission received from Section territories during the fiscal year was more than 94 per cent of the corresponding number for the preceding fiscal year (1,209 and 1,280, respectively). Many of the Sections have appointed committees to study the qualifications of their members and to urge those who are fully qualified for a higher grade to submit their applications for transfer.

**Table I—Section Meetings Held During Year Ending April 30, 1932**

| | A.I.E.E. Members | | Meetings During Year | | |
|---|---|---|---|---|---|
| Section | Aug. 1930 | Aug. 1931 | No. | Avg. Attendance | Avg. Attendance as Per Cent of Membership Aug. 1931 |
| Akron | 79 | 75 | 7 | 274 | 365 |
| Atlanta | 111 | 102 | 6 | 223 | 218 |
| Baltimore | 191 | 217 | 8 | 274 | 126 |
| Birmingham | 52 | 38 | | | |
| Boston | 535 | 513 | 8 | 598 | 117 |
| Chicago | 1,117 | 1,098 | 4 | 332 | 30 |
| Power Group | | | 6 | 134 | |
| Cincinnati | 169 | 168 | 11 | 132 | 78 |
| Cleveland | 290 | 274 | 10 | 789 | 288 |
| Columbus | 71 | 62 | 9 | 432 | 696 |
| Connecticut | 271 | 263 | 6 | 112 | 43 |
| Dallas | 122 | 114 | 9 | 91 | 80 |
| Denver | 156 | 154 | 11 | 66 | 43 |
| Detroit-Ann Arbor | 336 | 310 | 10 | 211 | 68 |
| Erie | 98 | 99 | 8 | 110 | 111 |
| Florida | | 42 | 3 | 37 | 88 |
| Fort Wayne | 76 | 80 | 6 | 69 | 86 |
| Houston | 75 | 71 | 9 | 51 | 72 |
| Indianapolis-Laf. | 88 | 88 | 8 | 126 | 143 |
| Iowa | 59 | 62 | 5 | 47 | 76 |
| Ithaca | 40 | 38 | 4 | 62 | 163 |
| Kansas City | 146 | 158 | 10 | 241 | 153 |
| Lehigh Valley | 287 | 271 | 7 | 141 | 52 |
| Los Angeles | 447 | 477 | 9 | 144 | 30 |
| Louisville | 49 | 53 | 10 | 150 | 283 |
| Lynn | 130 | 134 | 15 | 558 | 417 |
| Madison | 56 | 55 | 6 | 52 | 94 |
| Memphis | 37 | 53 | 12 | 40 | 75 |
| Mexico | 91 | 94 | 8 | 45 | 48 |
| Milwaukee | 227 | 221 | 10 | 203 | 92 |
| Minnesota | 95 | 96 | 7 | 771 | 803 |
| Montana* | | 26 | 4 | 47 | 181 |
| Nebraska | | 55 | 2 | 130 | 236 |
| New York | 3,865 | 3,794 | 4 | 831 | 22 |
| Communication Group | | | 3 | 367 | |
| Illumination Group | | | 3 | 208 | |
| Power Group | | | 4 | 331 | |
| Transportation Group | | | 3 | 367 | |
| Niagara Frontier | 155 | 176 | 11 | 88 | 50 |
| North Carolina | 77 | 83 | 2 | 148 | 178 |
| Oklahoma City | 46 | 64 | 11 | 197 | 308 |
| Philadelphia | 795 | 760 | 8 | 127 | 17 |
| Pittsburgh | 790 | 724 | 9 | 268 | 37 |
| Pittsfield | 147 | 137 | 11 | 677 | 494 |
| Portland | 132 | 121 | 11 | 76 | 63 |
| Providence | 78 | 80 | 5 | 110 | 137 |
| Rochester | 108 | 103 | 9 | 182 | 176 |
| St. Louis | 246 | 256 | 8 | 317 | 124 |
| San Antonio | 66 | 65 | 8 | 57 | 88 |
| San Francisco | 484 | 460 | 9 | 162 | 35 |
| Saskatchewan | 33 | 39 | 3 | 35 | 90 |
| Schenectady | 485 | 456 | 11 | 207 | 45 |
| Seattle | 228 | 218 | 10 | 93 | 43 |
| Sharon | 114 | 111 | 9 | 173 | 156 |
| Southern Virginia | 91 | 85 | 3 | 55 | 65 |
| Spokane | 47 | 46 | 9 | 42 | 91 |
| Springfield, Mass. | 91 | 99 | 9 | 460 | 464 |
| Syracuse | 67 | 68 | 3 | 205 | 301 |
| Toledo | 72 | 87 | 13 | 272 | 312 |
| Toronto | 398 | 388 | 16 | 137 | 35 |
| Urbana | 37 | 36 | 7 | 85 | 236 |
| Utah | 62 | 58 | 9 | 46 | 79 |
| Vancouver | 90 | 91 | 12 | 50 | 55 |
| Washington | 176 | 183 | 7 | 92 | 50 |
| Worcester | 61 | 61 | 9 | 146 | 239 |
| Total......60 | 14,596 | 14,410 | | | |

Total number of meetings........ 497
Total attendance............... 105,325
*Organized September 12, 1931.

Arrangements made in recent years involving interesting developments in activities were continued in effect. Notable among these are: the 2 joint meetings of the Pittsfield and Schenectady Sections each year for the presentation of papers by younger members in competition for prizes; the practise of Sections to have programs supplied largely by their members; the effective public speaking instruction sponsored by the New York Section; special joint meetings with students in several Sections; the lecture courses sponsored by the Chicago Section; and local prize competitions held by many Sections. The

Cleveland Section distributed with the notice of its December meeting a questionnaire designed to learn in considerable detail the wishes of its members with respect to the types of meetings to be held in the future. The suggestions received are expected to be of material aid in the planning of meetings for this coming year.

The group (power, transportation, communication, illumination) activities of the Chicago and New York Sections were continued with excellent results. The Chicago Section and other local engineering organizations continued the arrangements for post-college education of engineers as begun in 1929. A review of these activities was published on p. 280–1 of the April 1932 issue of ELECTRICAL ENGINEERING.

Resolutions were adopted by the board of directors October 23, 1931, urging the Sections to consider organizing engineers' unemployment relief committees in cooperation with other engineering groups. A large number of the Sections participated in the formulation and execution of plans directed toward making work and furnishing financial assistance to engineers in need for whom positions could not be secured. A review of these efforts and their results is contemplated for an early issue of ELECTRICAL ENGINEERING.

In the fifth annual report on Section and Branch activities covering the fiscal year ending April 30, 1932, considerable information concerning meetings is given. This information is presented herewith in Tables I and II.

**Table II—Section Meetings Held During Last 3 Fiscal Years**

| | Fiscal Year Ending April 30 | | |
|---|---|---|---|
| | 1930 | 1931 | 1932 |
| Number of Sections | 56 | 59 | 60 |
| Number of meetings held | 480 | 491 | 497 |
| Average number of meetings | 8.6 | 8.3 | 8.3 |
| Total attendance | 84,727 | 108,523 | 105,325 |
| Avg. attendance per meeting | 177 | 221 | 212 |

## Branch Activities for Fiscal Year Summarized

The interest in the Student Branch activities which has been so marked for the last 2 or 3 years is still as alive as ever, as evidenced by the number of meetings held and the large number of student papers delivered. There is no doubt that this form of activity of the Student Branches, if continued, is destined to produce electrical engineers who can write good technical papers and present them clearly and effectively.

The committee on Student Branches, in addition to giving electrical engineering students training in the activities of the Institute while they are still in college, has been working for the past year on the problem of improving the grade of the student who applies for courses in electrical engineering in the educational institutions. For the purpose of encouraging those who should go into electrical engineering, and to discourage those who are unfitted for such a career, the committee prepared a 32-page booklet. Following a preliminary distribution of this booklet, requests for about 9,000 additional copies were received.

**Table I—Branch Meetings Held During Year Ending April 30, 1932**

| Branch | Meetings During Year: Number | Avg. Attendance | Approx. No. of Talks by Students |
|---|---|---|---|
| Akron, University of | 8 | 12 | 11 |
| Alabama Polytechnic Inst | 13 | 18 | 7 |
| Alabama, University of | 9 | 161 | 3 |
| Arizona, University of | 28 | 8 | 17 |
| Arkansas, University of | 15 | 29 | 39 |
| Armour Institute of Tech | 12 | 50 | |
| British Columbia, Univ. of | 12 | 24 | 17 |
| Brooklyn, Poly. Inst. of | 8 | 53 | 11 |
| Bucknell University | 10 | 18 | 6 |
| California Institute of Tech | 6 | 49 | |
| California, University of | 15 | 40 | 9 |
| Carnegie Institute of Tech | 4 | 38 | 2 |
| Case School of Applied Science | 7 | 56 | 6 |
| Catholic Univ. of America | 6 | 36 | 1 |
| Cincinnati, University of | 6 | 39 | |
| Clarkson Col. of Technology | 9 | 36 | 6 |
| Clemson Agricultural College | 12 | 34 | 27 |
| Colorado State Agr. Col | 6 | 19 | 1 |
| Colorado, University of | 15 | 50 | 8 |
| Cooper Union | 3 | 49 | |
| Cornell University | 4 | 42 | |
| Denver, University of | 18 | 29 | 3 |
| Detroit, University of | 8 | 55 | 2 |
| Drexel Institute | 9 | 21 | 6 |
| Duke University | 8 | 17 | 15 |
| Florida, University of | 12 | 52 | 6 |
| Georgia School of Technology | 7 | 74 | |
| Harvard University | 8 | 71 | 4 |
| Idaho, University of | 5 | 32 | 3 |
| Illinois, University of | 16 | 65 | 6 |
| Iowa State College | 8 | 127 | 4 |
| Iowa, State University of | 22 | 56 | 25 |
| Kansas State College | 18 | 52 | 10 |
| Kansas, University of | 11 | 57 | 9 |
| Kentucky, University of | 8 | 40 | 5 |
| Lafayette College | 9 | 38 | 8 |
| Lehigh University | 5 | 60 | 7 |
| Lewis Institute | 12 | 67 | 4 |
| Louisiana State University | 4 | 20 | 3 |
| Louisville, University of | 9 | 17 | 12 |
| Maine, University of | 6 | 20 | 10 |
| Marquette University | 8 | 50 | 6 |
| Massachusetts Inst. of Tech | 11 | 91 | 3 |
| Mich. Col. of Mining & Tech | 8 | 29 | 5 |
| Michigan State College | 12 | 22 | 5 |
| Michigan, University of | 12 | 71 | 1 |
| Milwaukee, School of Engg. of | 7 | 104 | 8 |
| Minnesota, University of | 8 | 51 | 4 |
| Mississippi State College | 4 | 28 | 2 |
| Missouri School of Mines & Met | 10 | 44 | 13 |
| Missouri, University of | 8 | 92 | 7 |
| Montana State College | 25 | 110 | 99 |
| Nebraska, University of | 11 | 45 | 6 |
| Nevada, University of | 6 | 32 | |
| Newark Col. of Engineering | 13 | 50 | 10 |
| New Hampshire, Univ. of | 19 | 35 | 21 |
| New Mexico, University of | 10 | 18 | 6 |
| New York, Col. of the City of | 16 | 38 | 2 |
| New York University | 11 | 15 | 17 |
| North Carolina State College | 9 | 31 | 7 |
| North Carolina, University of | 6 | 36 | |
| North Dakota Agr. College | 10 | 49 | 13 |
| North Dakota, University of | 14 | 18 | 10 |
| Northeastern University | 4 | 78 | |
| Notre Dame, University of | 14 | 200 | 26 |
| Ohio Northern University | 8 | 31 | 3 |
| Ohio State University | 8 | 36 | |
| Ohio University | 8 | 34 | 4 |
| Oklahoma A. & M. College | 13 | 28 | 17 |
| Oklahoma, University of | 9 | 31 | 4 |
| Oregon State College | 8 | 49 | 5 |
| Pennsylvania State College | 9 | 60 | 17 |
| Pennsylvania, University of | | | |
| Pittsburgh, University of | 32 | 115 | 28 |
| Pratt Institute | 14 | 38 | 11 |
| Princeton University | 4 | 9 | 3 |
| Purdue University | 7 | 161 | 2 |
| Rensselaer Polytechnic Inst | 6 | 127 | 7 |
| Rhode Island State College | 18 | 19 | 20 |
| Rice Institute | 16 | 24 | 12 |
| Rose Polytechnic Institute | 8 | 43 | 6 |
| Rutgers University | 6 | 18 | 5 |
| Santa Clara, University of | 10 | 85 | 2 |
| South Carolina, University of | 22 | 36 | 27 |
| So. Dakota State School of Mines | 9 | 35 | 2 |
| South Dakota, University of | 2 | 23 | |
| Southern California, Univ. of | 24 | 28 | |
| Southern Methodist Univ | 10 | 31 | 3 |
| Stanford University | 11 | 29 | 5 |
| Stevens Institute of Tech | 11 | 42 | 2 |
| Swarthmore College | 1 | 85 | 1 |
| Syracuse University | 24 | 31 | 37 |
| Tennessee, University of | 11 | 71 | 4 |
| Texas, A. & M. College of | 10 | 128 | 12 |
| Texas Technological College | 8 | 17 | 10 |
| Texas, University of | 9 | 26 | 7 |
| Utah, University of | 12 | 41 | 10 |
| Vermont, University of | 11 | 20 | 4 |
| Virginia Military Institute | 12 | 67 | 43 |
| Virginia Polytechnic Inst | 18 | 49 | 43 |
| Virginia, University of | 3 | 16 | 5 |
| Washington, State College of | 13 | 35 | 8 |
| Washington University | 6 | 31 | 1 |
| Washington, University of | 18 | 28 | 4 |
| West Virginia University | 16 | 29 | 90 |
| Wisconsin, University of | 7 | 58 | 7 |
| Worcester Polytechnic Inst | 2 | 29 | 1 |
| Wyoming, University of | 12 | 14 | 10 |
| Yale University | 2 | 30 | |
| Total | 109 | | 1,066 |
| Total number of meetings | | 1,135 | |
| Total attendance | | 54,197 | |

**Table II—Branch Meetings Held During Last 3 Fiscal Years**

| | Fiscal Year Ending April 30 | | |
|---|---|---|---|
| | 1930 | 1931 | 1932 |
| Number of Branches | 106 | 109 | 109 |
| Number of meetings held | 1,009 | 1,137 | 1,135 |
| Average number of meetings | 9.5 | 10.4 | 10.4 |
| Total attendance | 50,401 | 51,807 | 54,197 |
| Average attendance per meeting | 50 | 46 | 48 |
| Number of student talks | 844 | 1,085 | 1,066 |

**Table III—Summary of Monthly Reports on Branch Activities Appearing in the November to June Issues, Inclusive, of ELECTRICAL ENGINEERING of the Last 5 Academic Years**

| | 1927–28 | 1928–29 | 1929–30 | 1930–31 | 1931–32 |
|---|---|---|---|---|---|
| No. of Branches Jan. 1 | 95 | 100 | 104 | 107 | 109 |
| Avg. no. of Branches reporting meetings per month | 58 | 56 | 60 | 67 | 68 |
| Avg. no. of Branches reporting student talks per month | 24 | 30 | 35 | 39 | 36 |
| Total no. of meetings | 807 | 806 | 891 | 957 | 956 |
| Total no. of student talks | 646 | 767 | 893 | 966 | 919 |

The committee on Student Branches also has contributed the chapter on electrical engineering for the pamphlet being prepared by The Engineering Foundation to contain information on the main divisions of engineering.

In Tables I to VI, inclusive, is given information which was presented in the annual report on Section and Branch activities, covering the fiscal year ended April 30, 1932.

### Table IV—Camparison of Branch Activities by Districts

| District | No. of Branches Jan. 1 | Avg. No. Meetings per Branch | Avg. Attendance per Meeting | Approx. Avg. No. Student Talks per Branches | No. of Branches Reporting 8 or More Student Talks |
|---|---|---|---|---|---|
| 1 | 13 | 9.5 | 42.5 | 8.7 | 4 |
| 2 | 18 | 8.3 | 51.3 | 10.7 | 5 |
| 3 | 8 | 10.3 | 37.8 | 7.3 | 4 |
| 4 | 17 | 9.8 | 47.0 | 12.3 | 6 |
| 5 | 16 | 10.5 | 75.0 | 6.9 | 3 |
| 6 | 9 | 10.7 | 32.5 | 5.9 | 4 |
| 7 | 14 | 10.9 | 42.0 | 10.7 | 8 |
| 8 | 7 | 14.3 | 31.5 | 4.7 | 2 |
| 9 | 6 | 13.5 | 58.1 | 21.5 | 3 |
| 10 | 1 | 11.0 | 24.3 | 17.0 | 1 |

### Table V—Conferences on Student Activities

| District | Location | Date |
|---|---|---|
| 1 | Rochester, N. Y. (North Eastern Dist. Mtg.) | 5/ 1/31 |
| 8 & 9 | Lake Tahoe, Calif. (Pacific Coast Conv.) | 8/27/31 |
| 7 | Kansas City, Mo. (South West Dist. Mtg.) | 10/23/31 |
| 4 | Gainesville, Fla. | 12/ 4/31 |
| 2 | Haverford College, Pa. | 3/14/32 |
| 5 | Milwaukee, Wis. (Great Lakes Dist. Mtg.) | 3/14/32 |
| 6 | University of Denver | 4/15–16/32 |

### Table VI—Student Conventions

| Sponsored by District | Location | Date | No. of Student Papers |
|---|---|---|---|
| 1 | Rochester, N. Y. (North Eastern Dist. Mtg.) | 5/1/31 | 8 |
| 8 & 9 | Lake Tahoe, Calif. (Pacific Coast Conv.) | 8/26/31 | 12 |
| 7 | Kansas City, Mo. (South West Dist. Mtg.) | 10/23/31 | 10 |
| 4 | Gainesville, Fla. | 12/4/31 | |
| Phila. and Lehigh Valley Sections | Haverford College | 3/14/32 | 4 |
| 5 | Milwaukee, Wis. (Great Lakes Dist. Mtg.) | 3/14/32 | 10 |
| 3 (and New York Section) | New York | 4/29/32 | 3 |

# Pearl Street Station Opened 50 Years Ago

September 4, 1932, marked the 50th anniversary of Thomas A. Edison's first permanent commercial incandescent lighting system. This first Edison system was the Pearl Street station and district in lower New York City.

The anniversary was celebrated by 2 events. The first, on September 4, was held at the site of the old station, 255–7 Pearl Street, at which many Edison veterans and men of prominence in the electric light and power industry were present. The second observance took the form of a dinner held on September 12, and was attended by representatives of the electrical industry and civic, scientific, and engineering bodies.

At its opening on September 4, 1882, the Pearl Street station served an area of about 1 sq mile in lower Manhattan, distribution being by about 15 miles of underground cable. The capacity of the station was approximately 750 hp, and supplied electric light to 59 customers.

**Trade Acceptances Urged for Financing.**—A concerted plan has been initiated by leading American industrialists to stimulate interest in the use of trade acceptances as a means for the expansion of the volume of credit available to industry. The use of trade acceptances has the effect of speeding up the turnover, increasing the net return, and improving the credit standing of business concerns, since collections would be expedited by the substitution of readily negotiable paper for slow open-book accounts. The trade acceptance method should be restricted to current transactions for purchases and sales of goods, and should not be extended to past due accounts. In order to give definite information concerning the trade acceptance method and to assist in determining the advisability of adopting this system in any particular business, circulars have been sent out by the National Industrial Conference Board, Inc., New York, N. Y., in which it has endeavored to set forth briefly the operations of the plan and the advantages to American industry which would result from its use.

# Section and Branch Joint Meetings Continue Successful

The cooperative relations between Institute Sections and neighboring Student Branches of the Institute have continued to receive much attention during the past year. The excellent methods developed for maintaining close contacts between Sections and Branches were continued, and the results are becoming increasingly apparent as more and more of the students who have participated in them subsequently have become active Section members.

Some of the principal cases of such cooperation during the past fiscal year and which resulted in obvious benefit both to members of the Sections and Branches, are given in the annual report on Section and Branch activities, covering the fiscal year ending April 30, 1932. This information is presented herewith in Tables I and II.

### Table I—Section or Joint Section and Branch Meetings With Active Student Participation

| Sections | Schools | Date | Student Talks | Attendance |
|---|---|---|---|---|
| No. Carolina | Univ. of No. Carolina | 11/10/31 | 1 | 115 |
| Portland | Oregon State College | 12/ 8/31 | | 74 |
| Pittsburgh | Univ. of Pittsburgh<br>Carnegie Inst. of Tech.<br>Univ. of W. Virginia | 1/12/32 | 6 | 340 |
| Los Angeles | Calif. Inst. of Tech.<br>Univ. of Southern Calif. | 3/ 8/32 | 5 | 106 |
| Cleveland | Case School of App. Sci. | 3/24/32 | 2 | 180 |
| Spokane | Univ. of Idaho<br>Wash. State College | 3/25/32 | 2 | 65 |
| Utah | Univ. of Utah | 3/30/32 | | 45 |
| Urbana | Univ. of Illinois<br>Purdue Univ.<br>Rose Poly. Inst. | 4/ 2/32 | | 166 |
| Columbus | Ohio State Univ. | 4/22/32 | | 44 |
| Total | | 9 | 16 | 1,135 |

### Table II—Section or Joint Section and Branch Meetings With Student Programs

| Section | Schools | Date | Student Talks | Attendance |
|---|---|---|---|---|
| Cincinnati | Univ. of Cincinnati | 5/14/31 | 6 | 80 |
| Oklahoma City | Univ. of Okla., Okla. A.&M. Coll. | 5/18/31 | 8 | 115 |
| Utah | Univ. of Utah | 5/18/31 | 4 | 20 |
| Portland | Oregon State College | 5/23/31 | 4 | 100 |
| Kansas City | Univ. of Kansas | 11/ 5/31 | 2 | 200 |
| Madison | Univ. of Wisconsin | 12/10/31 | 3 | 53 |
| Urbana | Univ. of Illinois | 1/ 6/32 | 4 | 31 |
| Dallas | Southern Methodist Univ. | 1/18/32 | 3 | 60 |
| Vancouver | Univ. of British Columbia | 3/ 7/32 | 3 | 47 |
| Louisville | Univ. of Louisville | 3/18/32 | 5 | 66 |
| San Francisco | Univ. of Calif., Stanford Univ., Univ. of Santa Clara | 4/15/32 | 3 | 128 |
| Bucknell Univ. | Penn. State College | 4/27/32 | 2 | 49 |
| Denver | Univ. of Colo., Univ. of Denver, Colo. Agri. Col., *Colo. School of Mines, Univ. of Wyoming | 4/29/32 | 4 | 65 |
| Total | | 13 | 51 | 1,014 |

* No Branch.

# Floodlighting Aids in Pushing Construction

ONE construction project of sufficient urgency to require 24-hr per day activity was the building of a 13,000,000-bushel grain elevator at the Port of Albany, N. Y. Night operations were facilitated by a floodlighting installation consisting of 2 wooden towers 60 ft high supporting 6 1,000-watt General Electric floodlights at each of 2 locations; these units were supplemented by 3 units located on the roof of a concrete mixing structure, making a total of 15 kw for the complete installation.

# Annual Economic Conference Held

The second annual economic conference for engineers was held at the engineering camp of the Stevens Institute of Technology, near Johnsonburg, N. J., August 27 to September 5, 1932. Attendance this year was particularly gratifying, and was distinguished by the presence of a number of individuals prominent in engineering and economic activities, as well as many others interested in acquiring a knowledge of the broader economic aspects of present day life. Perhaps the most important thing about the conference was the fact that it evidenced a considerable desire on the part of engineers to assist in understanding and solving the large scale problems of political economics, the creation of which problems engineering accomplishments are held at least partially responsible.

The morning lectures continued throughout the 10 days of the conference, and were divided into 2 sessions. One on the subject of "Money" was conducted by Prof. W. D. Ennis, head of the department of economics of engineering at Stevens Institute of Technology, and the other on the subject of "Banking" was conducted by A. V. Shaw, investment counsel, of New York, N. Y. The afternoons were left free for any activities desired, which included swimming in the spring-fed lake at the camp, and golf and tennis at other points in the vicinity. Evenings were devoted to a series of conferences on various subjects, each under the leadership of an authority in his particular field.

In addition to analyzing the existing economic system, definite suggestions were made at these conferences for remedying ills and assisting in the stabilization of prices and industrial activity. These suggestions might be grouped roughly into 2 classes, one of which is the modification of the existing system by measures under government control and for the purpose largely of regulating credit, and the other contemplating more radical alterations in the system. It is felt that those present at these conferences obtained a clearer idea of the more or less mysterious forces underlying economic changes, and were left with a definite desire to be of assistance in the solution of economic problems.

# Southern California Power Official Dies

Russell H. Ballard, president of the Southern California Edison Company, Ltd., died of pneumonia at his home in Los Angeles, Calif., August 24, 1932. Mr. Ballard was born in Hamilton, Ontario, Canada, July 26, 1875, and came to the United States in 1883, working as an office boy in the Thomson, Houston Electric Company in Chicago, Ill. He was with the treasury department of the General Electric Company, Schenectady, N. Y., from 1890 to 1893, and was placed in charge of collections and credits for this company in the southern states, with headquarters at Atlanta, Ga., in 1896.

Except for about 4 years between 1900 and 1904, Mr. Ballard has lived in Los Angeles since 1897, serving the Southern California Edison Company, Ltd., and its predecessors. Starting first as bookkeeper and later becoming auditor, Mr. Ballard progressed steadily through the company's organization, being appointed vice-president and general manager in 1924, and president in March 1928. His organizing and operating genius was recognized throughout the industry.

He was a past-president of the National Electric Light Association and the Pacific Coast Electrical Association, and held membership in the Franklin Institute of Philadelphia, Pa. He has been the recipient of many honors and was the first to receive the John B. Miller Medal for distinguished service to his own company. In recent years Mr. Ballard has been identified prominently with community work in Los Angeles.

G. C. Ward (M'24) its senior vice-president will direct the Edison company's activities "with the advice and counsel of the enlarged executive committee" according to an official announcement recently made which stated that any adjustment in the management that may become necessary by reason of Mr. Ballard's death will be deferred.

# "5-Watt" Lamps Which Average 12 Watts

Incandescent lamps may and do vary with respect to light output and efficiency—qualities not designated on the lamp. The public, however, should be able to rely upon the substantial correctness of the watts designation which does appear on the lamp.

Recently Japanese lamps have been found upon the American market bearing "5-watt" designations. Electrical Testing Laboratories, Inc., New York, N. Y., on behalf of member companies of the Association of Edison Illuminating Companies, having surveyed these products, find that such lamps are anything but 5 watts, averaging about 12 watts (as shown in Table I) and ranging as high as 20 watts. Such misleading marking of incandescent lamps is inexcusable, these laboratories contend.

**Table I—Measurements of Wattage of Japanese Lamps, Rated at 5 Watts, Purchased in Various Cities**

| City | Number Measured | Average Watts |
|---|---|---|
| Detroit | 23 | 11.2 |
| Warren | 10 | 10.6 |
| Boston | 53 | 11.1 |
| Philadelphia | 24 | 11.8 |
| Waterbury | 11 | 11.9 |
| New York | 39 | 11.7 |
| Chicago | 13 | 13.9 |
| Butte | 2 | 11.1 |
| St. Louis | 37 | 12.5 |
| Youngstown | 2 | 13.4 |
| Total | 214 | 11.8 |

—From an article appearing in *Electrical World* for August 20, 1932, p. 253.

**A New Series of Magnet Steels.**—The perfection of a new series of magnet steels by Dr. T. Mishima, an assistant professor at the Tokyo Imperial University of Tokyo, Japan, is announced in the July 1932 issue of *Ohm*, a Japanese magazine devoted to electrical engineering. A translation of the original announcement prepared by J. A. Rabbitt and Dr. T. Fujiwara of the Japan

Nickel Information Bureau, Tokyo, states that these new magnet steels are called by the inventor "MK" steel and are characterized by a very high order of permanence. The announcement says that the coercive force is claimed to be about 9 times that of the usual tungsten magnet steels and $2^1/_2$ times that of the best cobalt magnet steels. The residual magnetism can be varied so that its value is between that of tungsten and cobalt magnet steels. The MK steels consist mainly of iron, nickel, and aluminum. A typical composition is 25 per cent nickel, 10 per cent aluminum, and the balance iron, but the nickel may be varied from 10 to 40 per cent and the aluminum from 1 to 20 per cent. The MK steels are not readily forged and therefore must be cast into the desired form. However, their desirable magnetic properties are developed by simple annealing and they are therefore free from the difficulties of quenching which is required with the tungsten steels. In addition, the announcement says that the magnetic properties of the MK steels do not change appreciably with increase in temperature even to the extent of several hundred deg C. They are said also to be magnetically stable when subjected to mechanical vibration or shocks.

# Letters to the Editor

CONTRIBUTIONS to these columns are invited from Institute members and subscribers. They should be concise and may deal with technical papers, articles published in previous issues, or other subjects of some general interest and professional importance. ELECTRICAL ENGINEERING will endeavor to publish as many letters as possible, but of necessity reserves the right to publish them in whole or in part, or to reject them entirely.

STATEMENTS in these letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the American Institute of Electrical Engineers.

## Has Man Benefited by Engineering Progress?

*To the Editor:*

From the articles printed in ELECTRICAL ENGINEERING on the question, "Has Man Benefited by Engineering Progress?" and the letters of comment they have elicited, it is plain we engineers feel moved to a certain searching of our hearts to determine whether we are living up to what we conceive to be our proper position in the community; and with this there goes also a disposition to inquire whether, on the part of the community, there is a readiness to accord us all the recognition to which we feel entitled. It is our belief, more or less definitely formulated, that most public questions are, in their essence, engineering problems, whose solutions should be sought, therefore, by the methods of our profession; and we tend to receive with some impatience what we regard as the snap judgments on these of politicians, financiers, and real estate operators, judgments that appear to us to be derived rather from the inner consciousness of the presenter than from that careful collection of data and that correct treatment of them to which we are used. We are accustomed to think, and now and then to say, that the competence to pass on these questions lies really with us, rather than with any of the other professions or callings; and we are wondering whether, if this be not generally admitted, the fault lies with the other professions, possibly jealous of us, or with the community at large, apparently oblivious to us, or with ourselves, for hiding our light under a bushel. We are asking ourselves, now, what, if anything, we may, can, or must do to set these things right.

It is being said among us, we must emerge from any seclusion where we may have been keeping ourselves, we must assume a leading part in civic and national affairs. . . . The picture is painted of our profession as the center from which shall emanate influences to guide our cities, our country, toward ideals of spaciousness and beauty, and of our publications as the inspiration and comfort of all that are fighting the good fight against ignorance, indifference, or turpitude. . . . This, briefly, is the picture some of us see in our minds' eyes; what is wrong with it?

Perhaps nothing, but, at any rate, it will be wise to look over the field more in detail, before deciding to enter the competition. For it is a competition. So far are our public problems from going a begging for solution that the want for an answer to any question of social policy is as uncommon as Byron found that for heroes to be, "When every year and month send forth a new one." . . . We wonder, and, as has been hinted, we envy; and we ask, if a physician or a jurist can do these things, why may not an engineer do them better? Ah, why? It will not be safe to leave that question behind us unanswered.

There is a welcome emancipation for the mind in considering unfamiliar things. About these, untrammelled by stubborn facts, the fancy may play; since we do not know the truth about them, we may paint them to suit us; if we do not confess our ignorance, and speak oracularly, we may succeed in having our utterances accepted at their face value. We may even attain to believing them ourselves, and thus may our dreams be in a fair way to come true. So it happens that, if a silk stocking manufacturer has visited London or Paris recently, and is asked what, from his observation while abroad, he would offer as a relief for the congestion in Philadelphia's streets, he does not hesitate to give a comprehensive answer. . . . But, is this what we are yearning to emulate?

Certainly not! We know that easier way is not for us. It is not that we assume any unhuman superiority; we were men before we were engineers. We will bet on a horse with any justice of the supreme court; we are as ready as the next man to tell a friend how to cure his cold; but if you ask us what is the correct ratio of the height of a building on Chestnut Street, between 10th and 11th, to the width of that street, we will say we do not know; and we stir uneasily, if we hear a clergyman answering that question offhand. The trouble is, these questions, as we recognized at the outset, are engineering questions, and we are estopped from answering them as do those in other walks of life. Those others, at whose ready-made pronouncements we have been smiling, are just as chary as we of resolving doubts within the provinces of their professions; the physician does not diagnose the disease without seeing the patient, nor the lawyer take the case without knowing all the evidence. These engineering problems are ours to solve, and ours only, but we must solve them in our way, and that way is by the collection and study of data. The engineering profession cannot undertake, in the blithe, light-hearted way of those we have been belittling, to take the lead in these public projects.

Must we, then, redraw our picture, and shape it farther from our heart's desire? Let us look over the field again. How fare these competitors of ours in the long run; do they finish the race? Seldom, if ever; we are justified in our reluctance to take them seriously. Their dreams, lacking both inspiration and perspiration, prove evanescent. Our rulers, the professional politicians, regard them with the tolerant contempt the professional has always for the amateur; that is the measure of their futility. If then, we might enter the field in our own way, handling technical questions as technicians, we should encounter no opposition. Is that a practicable course?

It would hardly seem so, for the conclusive reason that we are not given, and cannot take, the opportunity for the collection of the essential data on most of these questions. . . we can easily see they often involve such sciences as psychology, economics, and sociology, all sciences that have great difficulty with the question, "How much?" when asked of their subject matter. Such sciences give the engineer nothing to take hold of. There may be such a technique as human engineering, or social engineering; and all engineers must include economic factors in their problems; but how far we are from effectually applying such sciences, in the true engineering sense, is quite clear from a reading of the series of articles that instigated this inquiry. Quite as able they are as anything from the bankers, the captains of industry, the statesmen, the educators; but it seems they should be taken as a salve, rather than as an excitant, for our itch to get our hands on the wheel of the ship of state. We are not yet ready, no readier than those we condemn.

Obviously then, a course of preparation is indicated. Just what form that should take is the first question to which we should address ourselves. A central bureau for the collection of data seems the first requisite. A closer union among all our national engineering organizations is another. It is the voice of the engineers of America, and not that of the electrical engineers alone, that should be heard on national questions. An ample headquarters and close communication with our outposts, we already have. Let us now bend our energies toward perfecting the preparation we need, deferring, until that is in operation, all further complaints of not being permitted the opportunities we feel we can seize when we are prepared.

Very truly yours,

RUDOLPH H. KLAUDER (A'97)
(7447 Devon St., Mt. Airy,
Philadelphia, Pa.)

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*To the Editor:*

A word of caution should be raised in the discussion about the mechanization of man's activities and about the assured deleterious influence of the increasing tendency of mankind to remain indoors.

The chocolate-brown skin of the beach habitue is a striking example of what the human body will do in order to protect itself from an overdose of the sun's radiation. Melanin is laid down in the skin to lessen the penetration of the light. Perfect health can be had with an infinitesimal amount of the solar radiation which an individual who lives out-of-doors absorbs.

The effect of drugs, of exposure to light, and of other stimuli follow well-known physiological laws which have more or less of a logarithmic character because of which a little goes a long way. Fish live out of range of the therapeutic effect of the sun's rays, and birds and the beasts of the forest and field are covered with scales, feathers, hair, wool and what not that most effectively keep the sun's rays away from nearly all of their skin. So it is evident that the skin need not be exposed to very much light.

A modern residence, be it a palace or overcrowded tenement house, possesses many and distinct advantages over the cool, damp, sweaty-walled cave without, for example, any semblance of toilet facilities.

Our getting into clothes has been gradual. Hundreds of generations of Caucasians, at least, have passed into and out of this earth since we first began to dress. Yet it would seem that the population of the earth is greater now than in any previous era. This is a pretty good indication that our present mode of life is as healthful as it has ever been.

The medical examinations of candidates for military service during the World War showed a greater percentage of physical defects among those from the rural districts than among those from the urban population in spite of the fact that the former were leading an outdoor life.

These conditions are greatly at variance with Bachem's quotation from Pearl, "Mortality is distinctly lower for outdoor than for indoor workers. This indicates the superior healthfulness of outdoor life." (See twelfth article of Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?" in Electrical Engineering for August 1932, p. 553–5.) It is a typical illustration of how biometrical data and observation can be interpreted to illustrate a particular tenet. Those who work outdoors invariably have more diversified tasks to perform and require a greater all-round exercise of mind and muscular coordination and, undoubtedly, for this important reason are also more inclined to be healthy.

The machine has been mankind's greatest boon and has given an unparalleled impetus to civilization. The great problem, with the enormous saving of time and effort thus effected, is not to urge mankind to seek pleasure on the picnic grounds or in the public amusement halls where paid performers entertain but to urge it to use gainfully the surplus energy which it now has as a result of mechanization. The mere seeking of pleasure and taking of recreation leave a less beneficial permanent trace of the satisfaction afforded than do more worthwhile things.

A people who are imbued with the spirit of ambition and are willing to sacrifice for education and advancement in the arts and sciences and even in commerce and industry will profit through a raising of the general level of desire above the base spirit of pleasure seeking, which, at least in part, now prevails. Very wisely the founders of our country put the pursuit of happiness after life and liberty, thereby, tacitly perhaps, recognizing that its consideration should not come first.

There should be fewer pool rooms and motion picture theatres and more schools, churches, and privately owned homes. Pleasure seeking in itself is invariably not so conducive to true happiness as is creative achievement.

Very truly yours,
Roy Kegerreis, M.D.
(A'14 and Life Member)
(311 N. Oak Park Ave., Oak Park, Ill.)

## Engineering Subjects in the College Program

*To the Editor:*

The measure of success achieved by the technical schools in training students depends largely upon the ability of the directors to keep up with the changes in business and to anticipate the trends of the future. It is more vital today than ever before that the graduate should be prepared to meet the rapidly changing conditions and requirements of business. A liberal margin of security, favored by natural isolation, aided business during the period through which we have just passed, to the extent that rigid economy and a high degree of efficiency was not necessary. The rapid advances made in transportation and communication facilities have limited the isolation previously enjoyed, and in turn raised the standards of efficiency.

Those changing conditions open a broader field for engineering; the fundamental purpose of which is to achieve maximum efficiency at minimum cost. To accomplish that the engineer must enter the field of management and business control. With the new fields in view the schools must recognize the increasing importance of teaching subjects pertaining to the present day practise of business. Practical business courses should be added wherever it is possible to insert them.

Alfred H. Lovell in his paper on "Engineering Subjects in the College Program" (see Electrical Engineering for August 1932, p. 568–71) outlines some of the changes that have been made in the curricula of the technical schools to provide a more complete business training. Mr. Lovell points out that many of the schools have omitted foreign languages. Subjects that have been carried along for years by precedence and pride. To eliminate them is a step forward.

The value of shop work has been questioned as it is rarely used in practise today. Standardization has had much to do with eliminating the need for local work. Parts can be secured on short notice from any section of the country, it is no longer a local affair. Although useful, shop work will undoubtedly follow foreign languages and be replaced by subjects more applicable to the work encountered in the field.

There has been a general increase in the number of hours of training given in the department of English, which is very commendable. Report writing is more necessary today than ever before and it should be stressed in that department.

A question has been raised as to the value of surveying. Personally I would defend it as it is by nature a specialized course in mathematics and provides excellent and exacting training. It is also a very practical subject. There are, however, many subjects drafted from older engineering courses that can be replaced by those concerning present day practises. A careful survey of that part of the curricula will help to solve the time problem confronting most schools of engineering and develop a more practical course.

Yours very truly,
Orrin S. Vogel (A'29)
(Atlanta, Ga.)

## Consumption, Production, Distribution

*To the Editor:*

The American Engineering Council committee, in its progress report entitled "The Relation of Consumption, Production, Distribution" (see Electrical Engineering for June 1932, p. 373–7) has attacked an extraordinarily difficult and broadly comprehensive subject and has made a remarkably good presentation of preliminary results obtained within the scope of money and time which have been available to the committee. The results thus far obtained justify the expression of hope that the committee may be given support to continue its studies.

The statement made by the committee of its points of attack is an excellent résumé of 8 important threads. The characteristic of research and adaptation is intermixed with all these threads. In my opinion the committee has not made enough of that—research coming first and adaptation being the process of applying the principles brought out by the results of the research. This application of these principles to daily affairs must be made in 2 ways, one being direct and the other being through education. The education ties back again into means for improving the research and thereby making continuous progress. I agree with the committee that the objective which they have stated is physically possible for the whole of western civilization. To accomplish such realization, however, it becomes necessary to view the world as it is, with the modes of life, as they are, founded upon our present day development of science and invention. We cannot suitably support social practises for the present day by excerpts from and references to the writings of Adam Smith, Hume, Ricardo, John Stuart Mill and their associates covering a period of a century and a half beginning substantially a quarter of a millennium in the past. Over-constant adherence to the tenets of these ancient writers on economics is one of the reasons of inutility which pertains to modern day doctrines of political economy as pronounced by the economists. Political economy must be adapted to the modes of life of the age in which the application is made.

The committee wisely concludes that suitable economic readjustment can be realized to a large degree in the United States even if it is not contemporaneously accomplished throughout the western world. This view has an optimistic tinge, but its soundness is well worth proving and is likely to be proved in the near days. Certain aspects of many of the philosophical arguments that have been broadcast from economists and international bankers during the last 2 years have had an unfortunate influence besides being inaccurate. Iteration of the cry that the joint troubles of the western world must be cured before we can recover from our own financial and industrial difficulties is disturbing as well as false. It is particularly disturbing because it misleads our people into believing that they can do nothing for themselves, but must idle until the international bankers have extricated us. The contrary is the fact and we need exhortation to wring our salvation out of our own environment. The sounder attitude of the American Engineering Council's committee pronouncement is refreshing to observe. We cannot wait for the bankers and economists to clear up the international situation for the mutual good of the world, however active their efforts may be, before we put forth efforts to ameliorate our own individual situation. We must put our shoulder to the wheel of our own cart in the meantime, while the international efforts proceed. Our own agricultural follies need better attention; our own industrial methods need modification and our industrial products given a character which will enable them to be sold without the application of artificial draft; our public expenditures require pruning, and happily this view has taken strong hold throughout the nation within the last few months; common thrift needs a new recognition as good practise.

The committee expresses 6 aspects of popular explanations of our present difficulties, of which explanations they find each and all to be questionable and/or inadequate. It is my opinion that the committee is right, except partially for the items of speculation and of instalment buying under the conditions which characterized affairs in this country during a few years past. These conditions led to unchecked high pressure selling of manufactured products associated with instalment payments, which (associated with reckless agriculture) had a considerable share in engendering the origins of financial panic and depression which are upon us. Neither bankers nor economists raised the voice of warning while industrial plant and industrial man-power in various industries were being expanded to the level required by a forced and over accelerated selling basis that inevitably led ultimately to stagnant markets caused by the margins of family incomes being absorbed in payments for past purchases. Engineers associated with the industries shook their heads in doubt over the situation, but they must also bear their share of responsibility because they did not raise their voices in argumentative protest. This may be an evidence of moral weakness in an unexampled situation, but precedents were lacking and perhaps we may pass that weakness over if suitable prevision is shown in the efforts for reestablishment of stability.

The committee is quite right in stating that investment bankers and the speculative public both had definite responsibilities in the matter. The engineers also had responsibilities and part of that responsibility must rest with the engineering schools on account of their failure to press effectively into economic philosophy a recognition of those features which distinguish the modern world from the world of Adam Smith, Hume, Richardo, John Stuart Mill, and their contemporaries of over a century and a half ago. Unless we thus modify our political economy, we are likely to lose the enviable standard of living and of intellectual activity which exists among the generality of our citizens.

One of the difficulties that the committee's report lays before us is associated with an inference that long-time planning should be a feature of industrial finance as well as government finance. The problem is to secure this important achievement without recourse to a degree of bureaucratic government control that verges on the edge of despotism, although perchance a benevolent despotism. A benevolent despot can do many things successfully, but we are not likely to approve such a guide for our lives even during the period of establishing a new political economy which is requisite to meet present conditions of our life which is wrapped up with the developments of science and invention of the last dozen decades. We must surely set up our economic situation in independence for ourselves, but this can be accomplished without refusing due consideration of mutual benefits which may arise from associated contacts with other countries. The discussion of the shorter-hour week in the report of the committee shows means for accomplishing this end and the general observations of the committee also are reassuring, provided those directly affected have been provided with convincing incentives for properly joining the satisfactions of leisure with the advantages of productivity. All who retain faith in the effectiveness of the human mind feel sure that this can be achieved.

The responsibility of devising serviceable measures for fending against the recurrence of depressions such as the present one, and their trains of hardship and suffering, rests upon those of us who live in this decade. To meet their part of this responsibility it is necessary for the engineers to bring to pass a cooperation which joins our scientific, pragmatic attitude to the philosophical tendency of the economists.

The engineering departments of our great educational institutions are well established in, and should continue to expand their creative work in, the borderland which overlaps with the natural sciences of mathematics, physics, chemistry, and biology. They also work actively, but are not equally well established, in the borderland which overlaps with economics. The latter borderland—contrasted with studying, investigating, and guiding phenomena of nature related to physical phenomena—consists in studying, investigating, and guiding the economic and social uses of structures, power, machinery, communication of intelligence and transportation, and guiding the influence of engineering on modes and conveniences of life. We have a good start in this, but with less intensive cultivation than on the mathematical-physics side. The appropriate manner of carrying on is by statistical and scientific investigation to establish facts and relations that are now perceived only dimly or perhaps not yet perceived at all. This cooperation should be and can be as fully established as on the mathematics-physics border. The object is to place this economics side of engineering on the same altitude of rigorous examination and reasoning as now characterizes the science side of engineering in the engineering schools. Collaterally, the object is to develop more rigorous investigation in this now neglected or only loosely studied field, while scrupulously avoiding any detracting from the efforts on the science side.

Besides leading their students to familiarity with the theoretical tenets of science and economics, the engineering departments in the engineering schools have the obligation to translate to the students a scholarly engineering vision of the principles of science and economics embodied in the works of man wrought in materials such as metals, stone, wood, and fiber, and the influence on civilization which is concomitant to those embodiments. "Machines, the slaves begotten of man's thoughts" have done us relative good, but until the articulation of engineering into economics is worked out in the engineering schools of university rank as fully as the articulation which now exists with mathematics, physics, chemistry, and biology, there will be danger of the relative good becoming relative evil. I do not charge this fault to the economists, theirs being a philosophical field; but as previously said we, the engineers, must bring to pass a cooperation which joins our scientific, pragmatic attitude to their philosophic tendency. From such cooperation brought to pass in engineering schools of high level, we may validly hope for the solution of such complex problems, for example, as the periodic recurrence of acute unemployment, and the ultimate formulation of effective means for prevention. Illumination may be secured on many other subjects, such as the perplexing subject of the responsibilities for mutual welfare which pertain between corporations, their employes and their stockholders, when both employes and stockholders may be in large numbers and both groups in general being composed of people of small means.

When the engineering departments have accomplished this cooperation in the institutions of university level and have secured a communion with the economists of a level and order equal to our communion with the scientists, we will have established our buttresses in both sides of the field of engineering and will be in position to cultivate most serviceably the full area of industrial science and economics. This method of securing a restudy of the tenets of political economy so that the structure of economics adapted to our present day mode of life may be erected is feasible, and it is so promising of important results that I hope that it may command support from the A.E.C. committee.

Very truly yours,
Dugald C. Jackson
(F'12 and Past-president)
(Massachusetts Institute of Technology, Cambridge, Mass.)

## Reactive Power Units and Terms

*To the Editor:*

Mr. Irwin's letter (see Electrical Engineering, August 1932, p. 597–8) calling attention to the disregard of the internationally adopted "var" as the unit of reactive power is very timely. As if to vindicate Mr. Irwin's admonition, there are published, on page 589–90 of the same issue, engineering abbreviations that are officially endorsed by the A.I.E.E. In this list the "var" is conspicuously missing, whereas the "rva" is duly displayed.

The relation between "rva" and "var" is obvious. In "var" the "r" that stands for "reactive," is put after the "va" instead of before. In this manner a name is obtained which not only is easily pronounceable, but also contains the elements of definition of the unit it stands for; which is more than can be said of the names of most of the established units.

"Var," therefore, seems a perfectly rational name for the unit of reactive power, and it is difficult to see on what grounds objection could be made to its general use which ought to be promoted by the A.I.E.E.

The unit most commonly applied in practise will, of course, be the "kilovar," abbreviated "kvar," which also is missing in the "standard" engineering abbreviations referred to. One need only compare the brief term "kilovar" with the lengthy "reactive kilovolt-ampere," or with the cacophonous spelled variety: "rkva," to become converted to the name adopted by the International Electrotechnical Commission.

Very truly yours,
Arthur A. Bolsterli (A'23)
(145 Church St., Hamden, Conn.)

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**Editor's Note:** As a comment on the above letter from Mr. Bolsterli, the following quotations from a letter sent to sponsoring organizations by Preston S. Millar (M'13), secretary of the American Standards Association's sectional committee on scientific and engineering symbols and abbreviations, are presented herewith:

"To the appendix of International Electrotechnical Commission recommendations attached to the report of the subcommittee on abbreviations for scientific and engineering terms, dated June 1932, which was distributed on June 3, 1932, to the sponsor organizations and to the members of the sectional committee, and which was submitted on June 15, 1932, to the American Standards Association, the following 3 units and abbreviations have been added:

"var (reactive volt-ampere)..................var
"kilovar (reactive kilovolt-ampere)...........kvar
"kilovarhour (reactive kilovolt-ampere-hour).kvarh

"These names of units and their abbreviations were officially adopted by the international Electrotechnical Commission at the plenary meeting held at Oslo, July 9, 1930. The list of I.E.C. abbreviations appended to the report of the subcommittee dated June 1932, was taken from an I.E.C. publication, which has not been revised since 1920. For this reason the 3 above terms and their abbreviations were unfortunately omitted. They are now added in order that the appendix may accurately represent the present day recommendations of the I.E.C."

It may be noted that the terms "var," "kilovar," and "kilovarhour" were officially adopted by the International Electrotechnical Commission on July 9, 1930. However, these terms are not consistent with American practise and have not been adopted as American standard. Therefore they were not included in the list of American tentative standard abbreviations published in Electrical Engineering for August 1932, p. 589–90. Further comments on this subject are invited.

# Overcompounded D-C Generators Without an Equalizer

*To the Editor:*

In this letter is discussed the division of load between 2 overcompounded d-c generators when the equalizer circuit is opened. The problem is not of importance practically but has considerable theoretical interest, as has been evidenced by the discussion aroused by the statement in "Direct Current Machinery," written by Harold Pender and published by John Wiley and Sons, that for a given total line current, if the speed of one generator increases after the equalizer has been opened, the current output of that generator decreases, and, the action being cumulative, the instability of operation without an equalizer is thus explained. Among the 5 other texts, in English, which have been consulted, there is virtually unanimous agreement that the converse holds, and the discussion mentioned above has centered on this point.

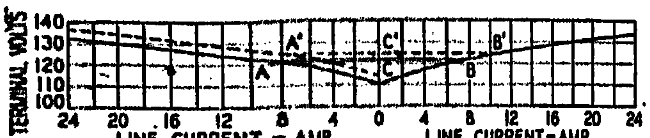


**Fig. 1. Voltage regulation curves of 2 d-c generators each rated 3 kw, 115–125 volts, 24 amp, 1,700 rpm**

To review briefly the minority argument which this letter attempts to justify further, consider Fig. 1, the voltage regulation curves (shown solid) of 2 generators supplying a total load current $AB$ at a voltage $OC$ when the current in the equalizer is zero. Opening the equalizer will have no effect on the system until some mechanical or electrical property changes. If for some reason the speed of generator 1 increases, the corresponding voltage regulation curve (dashed in Fig. 1) will be above the former curve, and the total load current, if it has not changed appreciably, will be represented by $A'B'$ ($= AB$ in magnitude). Hence, since $A'C'$ is less than $AC$, the current output of generator 1 will have decreased despite the increase in speed of this machine.

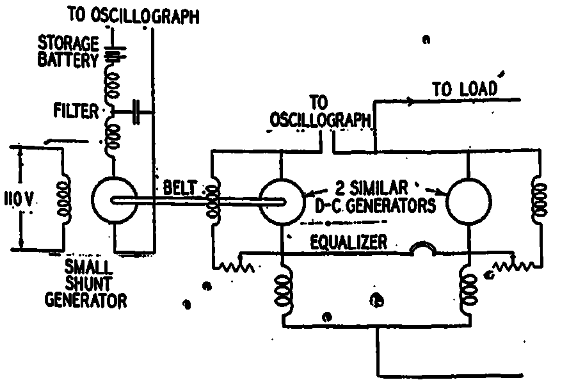
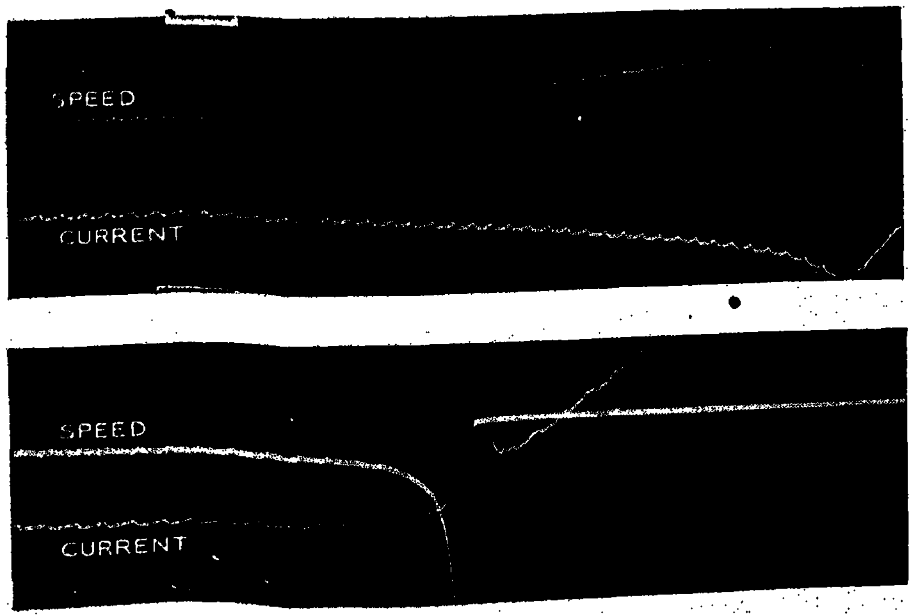


**Fig. 2. Connections for the 2 d-c generators represented in Fig. 1**

It is obvious that this argument can be only approximate, since the voltage regulation curves are determined for steady state conditions whereas the unstable condition of the system is essentially not a steady state condition. This has been the crux of many criticisms in which it has been contended that an increase in the speed of generator 1 increases the terminal voltage, hence causes that machine to increase its current output; the action is cumulative and consequently, according to this argument, the machine which increases speed ultimately carries all the load and may drive the other generator as a motor.

The oscillogram of Fig. 3 shows current and speed of one of a pair of similar generators (Fig. 2), the voltage regulation curves of which are pictured in Fig. 1. (Speed was measured by belting a small shunt generator to the machine and inserting a storage battery in the output circuit so that the voltage at the oscillograph was proportional to the difference between the actual speed and some datum near 1,700 rpm. An upward deflection of a curve on the oscillograms indicates an increase in the corresponding quantity.) The oscillogram is typical of many. It covers a time interval of 15 sec, and was obtained by simultaneously starting the photographic record and opening a circuit breaker in the equalizer, the current in the latter being zero. The portion of the oscillogram to the right of the peaks in the curves shows the readjustment following the reclosing of the circuit breaker in the equalizer. In this case the process took place comparatively slowly, the speed increasing while the current was decreasing. Fig. 4 shows the speed decreasing as the current increased. The action in this case took place rapidly after it was once started; the speed decreased sufficiently to cause a fuse in the corresponding oscillograph circuit to burn out, giving rise to the straight heavy curve in the right half of the figure, while the current, neglecting part of the curve due to overswing of the oscillograph element, increased rapidly and almost regularly.



**Figs. 3 (Above) and 4 (Below). Oscillograms of machines shown in the diagram of Fig. 2**

These oscillograms show conclusively that the majority argument given in the third paragraph of this letter cannot be of universal application. It cannot be claimed, however, that the oscillograms prove completely the other point of view. The problem is one which depends on many factors—the system would be unstable without an equalizer if the speeds remained constant—but the oscillogram of Fig. 3 does indicate that for the particular case the changes took place so slowly, comparatively, that the analysis using the steady state regulation curves would be expected to indicate at least qualitatively the action.

Very truly yours,

J. G. Brainerd (A'32)
(Moore School of Electrical
Engineering, University of
Pennsylvania, Philadelphia,
Pa.)

# Engineering Foundation

## A Reading List in Economics and Sociology

Engineers recently have exhibited a marked increase of interest in economics and sociology, and in the relation of engineering thereto. This interest appears to have become widespread and purposeful. To assist readers in these fields, The Engineering Foundation includes in its Research Narrative No. 190, the list of books and articles given below. The Engineering Foundation states that mention of a book in this list is not intended as an endorsement, nor should omission be taken to mean disapproval, nor has the order any significance. These books listed present varieties of subjects and views.

The Engineer in a Changing Society, W. E. Wickenden, Elec. Engg., July 1932, p. 465–71.

Sociology of City Life, Niles Carpenter, Longmans, Green & Co., New York, 1931. $3.90.

Population Problems, Warren S. Thompson, McGraw-Hill Book Co., New York, 1930. $3.75.

The Instincts of the Herd in Peace and War, William Trotter, The Macmillan Co., New York, 1930. $1.50.

The Epic of America, James Truslow Adams, Little, Brown and Co., Boston, 1931. $3.75.

The Direction of Human Evolution, Edwin Grant Conklin, Charles Scribner's Sons, New York, 1922. $2.50.

The Great Analysis, William Archer, Williams and Norgate, Ltd., London, 1931. 2 shillings.

Our Changing Civilization, John Herman Randall, Jr., Frederick A. Stokes Co., New York, 1929. $3.00.

Taming Our Machines, Ralph E. Flanders, Richard R. Smith, Inc., New York, 1931. $2.50.

Progress and Poverty, Henry George, Baker & Taylor Co., New York, new edition 1931. $1.00.

Business vs. Finance, David Cushman Coyle, Published by author, New York, 1932. 60 cents.

Business Cycles, Wesley C. Mitchell, National Bureau of Economic Research, New York, 1927. $6.50.

The Growth of American Trade Unions, Leo Wolman, National Bureau of Economic Research, New York, 1924. $3.00.

Health and Wealth, Louis I. Dublin, Harper & Bros., New York, 1928. $3.00.

Pathways Back to Prosperity, Charles Whiting Baker, Funk & Wagnalls Co., New York, 1932. $2.50.

Jobs, Machines and Capitalism, Arthur Dahlberg, The Macmillan Co., New York, 1932. $3.00.

The Swope Plan (for Stabilizing Industry), Gerard Swope (edited by J. George Frederick), The Business Bourse, New York, 1931. $3.50.

New Roads to Prosperity, Paul M. Mazur, The Viking Press, New York, 1932. $2.00.

Emotion as the Basis of Civilization, Henry S. Dennison, Charles Scribner's Sons, New York, 1928. $5.00.

Emotional Currents in American History, Henry S. Dennison, Charles Scribner's Sons, New York, 1932. $5.00.

The World's Economic Dilemma, Ernest M. Patterson, McGraw-Hill Book Co., New York, 1931. $3.50.

The Tragedies of Progress, Gina Lombroso, E. P. Dutton & Co., New York, 1931. $3.75.

Toward Civilization, Edited by Charles A. Beard, Longmans, Green & Co., New York, 1930. $3.00.

Economic Behavior, 2 Vols., Atkins, Edwards, Friedrich, Houghton Mifflin Co., Boston, 1931. $8.50.

Laissez-Faire and Communism, John Maynard Keynes, New Republic, Inc., New York, 1931. $1.00.

What Price Progress? Hugh Farrell, G. P. Putnam's Sons, New York, 1926. $2.50.

Power Control, H. S. Rausenbush and Harry W. Laidler, New Republic, Inc., New York, 1931. $1.00.

New Russia's Primer, M. Ilin (translated by George S. Counts and Nucia P. Lodge), Houghton Mifflin Co., Boston, 1931. $1.75.

Impressions of Soviet Russia and the Revolutionary World, John Dewey, New Republic, Inc., New York, 1931. $1.00.

Piatiletka: Russia's 5-Year Plan, Michael Farbman, New Republic, Inc., New York, 1931. $1.00.

## Research Procedure Committee Established

With the approval of the 4 principal engineering societies, and following a recommendation by the endowment methods committee of United Engineering Trustees, Inc., a research procedure committee has been established by The Engineering Foundation. The members of this committee appointed for the year 1932 and the societies which they represent are: Thaddeus Merriman, American Society of Civil Engineers; F. M. Becker, American Institute of Mechanical Engineers; W. H. Fulweiler, The American Society of Mechanical Engineers; L. W. Chubb (F'21), American Institute of Electrical Engineers; and E. DeGolyer, and D. R. Yarnall, Engineering Foundation.

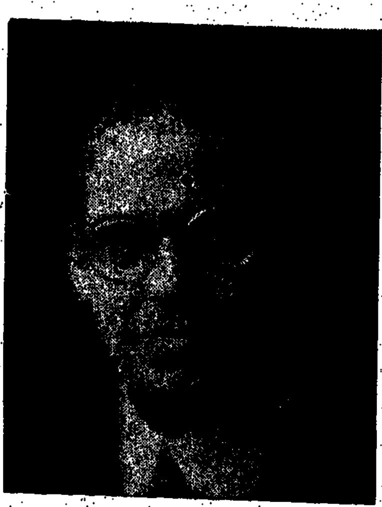
The duties of this committee are to aid The Engineering Foundation in ascertaining and meeting the research needs of the 4 engineering societies and in making intelligent selections among the numerous projects in which these societies are individually and collectively interested.

# Personal

P. H. Chase (A'12, M'18) chief engineer of the Philadelphia Electric Company, Philadelphia, Pa., will continue as chairman of the Institute's technical committee on power transmission and distribution for the year following August 1, 1932. Mr. Chase is a native of New Hampshire. He was graduated from Dartmouth College in 1907 with the degree of A.B., received the degree of S.B. in E.E. from Massachusetts Institute of Technology 2 years later, and the degree of M.E.E. from the Graduate School of Applied Science, Harvard University, in 1910. Following the completion of these studies he joined the Public Service Electric Company of New Jersey as assistant to the superintendent of distribution for Newark, N. J., and for the greater portion of 2 years had general supervision over the commercial and railway substations of the Newark district. In 1912 he was transferred to the company's engineering department, at first reporting to the electrical engineer in charge of electrical design and construction of power stations, but shortly advancing to the office of assistant engineer, his work covering all phases of estimating costs, preliminary and final design of power stations and substations, making up specifications, and the supervision of construction. For 4 years he was chief electrical engineer for the American Railways Company. He joined the Philadelphia Electric Company in 1921 as assistant engineer of the transmission and distribution division; in 1928 he was advanced to the position of engineer in charge of the division. Mr. Chase has been active in several of the representative engineering societies; in the Pennsylvania Electrical Association he has been, in turn, chairman of the overhead systems committee, technical section chairman, treasurer, vice-president, and for the year 1926–7, president. He is past chairman of the Institute's Philadelphia Section, holds membership in the National Electric Light Association, the Illuminating Engineering Society, and The American Society of Mechanical Engineers. He also is a member of the Engineers' Club of Philadelphia, the Penn Athletic Club, and the Philadelphia Country Club. Other committee work for the A.I.E.E. has included service as a member of the committee on protective devices 1918–25, standards 1917–22, and technical program 1930–32. His membership on the power transmission and distribution committee dates from 1924 continuing in unbroken service, his chairmanship dating from 1930.

E. L. Moreland (A'11, F'21) of Jackson and Moreland, Consulting Engineers, Boston, Mass., has received his reappointment as chairman of the Institute's technical committee on transportation, to which he first was appointed in 1931. Mr. Moreland was born at Lexington, Va., and in 1905 was graduated from The Johns Hopkins University, Baltimore, Md., with the degree of A.B. in mathematics and physics. In 1908 he entered the employ of D. C. Jackson (A'87, F'12, and past-president) and W. B. Jackson (A'97, F'13) consulting engineers in Chicago, Ill., and Boston, Mass., and served as a personal assistant to Mr. D. C. Jackson, senior member of the firm. In 1912 Mr. Moreland was made manager of the Boston office of this firm, and in 1916 became one of the partners. From 1918 to 1919 he served first as captain and then major in the engineers corps, American Expeditionary Forces, on a technical board charged with the procurement of electrical and mechanical power for A.E.F. activities; also as technical executive on the War Damage Board, which was created to advise the American delegates to the Peace Conference with reference to damages to physical property caused in the allied countries by the war. Upon return from military service the partnership with D. C. Jackson was formed. The principal activities of the firm are as consulting engineers on the design and supervision of construction of power plants, and transmission and distribution systems for public utilities and large industrial plants; and on railroad electrifications, valuations, and rate investigations. Among the most conspicuous pieces of work handled by the firm recently have been the electrification of the Great Northern Railway through the Cascades and the electrification of the suburban service of the Lackawanna Railroad out of Hoboken, N. J. In Institute activities Mr. Moreland has served as chairman of the Boston Section; chairman of the electrical machinery committee's subcommittee on rectifiers, as well as on the full committee from 1929 to 1931; on the power generation committee 1929–31; and on the technical program committee 1931–32. He was the Institute's

P. H. CHASE


CHESTER W. RICE

E. L. MORELAND

F. O. SCHNURE

C. W. DRAKE

R. A. BEEKMAN

representative on and chairman of the sectional committee on mercury arc rectifiers organized under American Standards Association procedure, and has served on the Institute's standards committee. Mr. Moreland has contributed frequently to Institute and other engineering publications. He is a member of the Engineers' Club, both in New York and in Boston, and of the University and City Clubs in Boston.

**C. W. Rice** (A'14, M'24) assistant to the vice-president in charge of engineering, General Electric Company, Schenectady, N. Y., by recent appointment was made chairman of the Institute's technical committee on research. Mr. Rice, who is the son of E. W. Rice, Jr. (past-president of the Institute, a member for life, and honorary chairman of the General Electric Company, Schenectady, N. Y.), was born at Lynn, Mass., and removed to Schenectady after the consolidation of the Thomson Houston and Edison General Electric companies. Early schooling was through home channels and in small private schools; at the age of 13 he entered the second form of the Albany Academy, Albany, N. Y., and in the fall of 1906, Harvard University, from which he received his S.B. degree in 1910 and his M.E.E. degree in 1911. The fall of 1911 he entered the testing department of the General Electric Company at Schenectady, and the following December joined the consulting engineering department, where he worked under Dr. C. P. Steinmetz. June 1917 he was transferred to the company's research laboratory, where his work was principally on submarine detection devices, supersonic sound signaling, piezoelectric devices, heat convection work, and a no inconsiderable amount of radio research investigation. He holds a number of patents in these fields. In May 1927 he was again transferred, to become assistant to the vice-president in charge of engineering in the engineering general department, his present office. Mr. Rice's contributions to technical literature have been many. He belongs to many representative professional and scientific bodies, including The American Physical Society, the American Association for the Advancement of Science, the Institute of Radio Engineers, and the Acoustical Society of America, of all of which he is a fellow; and a member of the American Chemical Society and the Optical Society of America. He is an enthusiastic member of the Schenectady Glider Club and of the Edison Club. Mr. Rice has served the Institute on the following committees: educational, 1916–19; electrophysics, 1918–27; telegraphy and telephony, 1922–24; communication, 1924–28; and the research committee of which he has just been made chairman, 1928–32.

**C. W. Drake** (A'20, M'21) general engineer of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., will continue to serve the Institute's technical committee on general power applications as its chairman for the coming year, in accordance with recent reappointment. Mr. Drake was born and educated in the city of Worcester, Mass., receiving his B.S. in E.E. from Worcester Polytechnic Institute in 1905. Leaving the New England section, he identified himself with the Westinghouse Electric and Manufacturing Company, at East Pittsburgh, and for the greater portion of 9 years worked with that organization's sales department as commercial or industrial engineer. In 1914 he was transferred to the Chicago office of the company, still as industrial engineer, but in 1919 returned to East Pittsburgh as general engineer of the industrial motor section. Since 1908 he has been in responsible charge of power and motor layouts for numerous industrial plants, paper mills, cement plants, and rubber mills. His work covered also the making of reports and estimates and supervision of installations and tests, leading to developments for special application of new types of drives and controls. He also did considerable work with central stations, assisting them in building up their motor load. The carrying out of tests and investigations took him practically to all parts of the United States. For over a year he had charge of a section of the Westinghouse company which was devoted to general engineering on electric welding, oil well machinery, and sugar mill equipment. His committee work with the A.I.E.E. includes 3 years on the committee on industrial and domestic power, 8 years on the general power applications committee, and 2 years on the technical program committee.

**F. O. Schnure** (A'23) who since 1916 has been identified with the Bethlehem Steel Company, Sparrows Point, Md., where he is now electrical superintendent, has been chosen as chairman of the Institute's technical committee on applications to iron and steel production for the current year. Mr. Schnure was born at Milton, Pa., and was graduated from Bucknell University with his B.S. in E.E. in 1914; his E.E. degree was conferred upon him in 1919. For a short period during 1914 he was with New York Railways as inspector of subway conduit construction. Then he joined D. C. and W. B. Jackson of Boston, Mass., as inspector and supervisor of overhead lines and power house appraisal of the Public Service Electric Company of New Jersey. The latter part of 1915 he joined the Pennsylvania Railroad Company at Altoona, Pa., as draftsman on power house design and layout. This was his position immediately preceding his joining the Bethlehem Steel Company, which he entered for miscellaneous electrical test work on maintenance and construction. After a year and a half in charge of electrical layout on a 50,000,000 dollar steel plant extension and $2^{1}/_{2}$ years as general foreman of electrical construction, he became foreman of the electrical repair shops. From this position he became assistant superintendent of the electrical department, later to be made superintendent, the office which he now holds. Mr. Schnure is also a member of the Institute's power generation committee, 1931–33, and in 1930 was elected president of the Association of Iron and Steel Electrical Engineers, a body in which he has been active over a considerable period of years, having served as chairman of its Philadelphia section in 1926–27, as a member of various of its committees. While in Baltimore, he served upon the executive committee of the A.I.E.E. local Section; also as a member of the educational committee of the Baltimore Chamber of Commerce during the years 1928–32. He has been a frequent contributor to technical literature both in papers before these several associations as well as through the technical press, writing on a variety of subjects dealing with the application of electricity to the steel industry.

**R. A. Beekman** (A'13, M'27) engineer of the federal and marine department of the General Electric Company, Schenectady, N. Y., continues for the ensuing year as chairman of the Institute's technical committee on applications to marine work. Mr. Beekman is a native of St. Louis, Mo., and received his B.S. in E.E. from the University of Missouri in 1910. July of that year he entered the testing department of the General Electric Company, from which he was transferred to the marine engineering department, now the federal and marine department. He holds several patents appertaining to electric ship propulsion; is a member of the Naval Architects and Marine Engineers, and has served on the Institute's committee on marine work since 1919, having been chairman since 1930. He also has been the Institute's representative on the American Marine Standards Committee since 1926. As chairman of the Institute's marine committee he is automatically a member of the Institute's technical program committee. Intimately associated with the General Electric Company's marine activities since 1912, he has spent considerable time at sea.

W. S. Culver (A'28) who for 47 years has been in the employ of the General Electric Company and its predecessors, and whose latest position with that company has been as district engineer of its East Central district with headquarters at Cleveland, Ohio, has retired from active service effective October 1, 1932. Mr. Culver has been a pioneer in the electrical industry, his first outside work being the installation of a 35-light incandescent generator. He was a close friend of Charles Francis Brush, of Cleveland, Ohio, the first man to bring out a commercial arc light system in this country and the founder of the old Brush Electric Company. Mr. Culver's first commercial connection in 1885. Mr. Culver also has spent considerable time in Manila installing electric light plants there. Upon his return to the United States he worked for awhile at the General Electric Company's Lynn plants, going to the central district then located in Cincinnati, Ohio, in 1902. His appointment as district engineer took place in 1907.

C. F. Hirshfeld (A'05) who is chief of the research department of the Detroit Edison Company, Mich., has been chosen vice-president of The American Society of Mechanical Engineers, an organization of which he has been a member since 1905. Always active in committee work, Doctor Hirshfeld has served the National Electric Light Association as chairman of its prime movers committee and of its engineering national section. For several years he was a representative of the electric light and power group of the American Standards Association; he has served on many committees of the A.S.M.E. In the committee work of the Institute, Doctor Hirshfeld has served on the following: industrial and domestic power, May–August 1922, power stations 1922–24, power generation 1924–31, standards 1923–30, and electrical machinery 1926–27. The degree of doctor of engineering was conferred upon him by Rensselaer Polytechnic Institute, Troy, N. Y., June 1932.

T. W. Carraway (A'21, M'32) who was vice-president of the Schwitzer-Cummins Company, Indianapolis, Ind., was transferred to Providence, R. I., as manager of the unit cooler department of the Grinnell Company, Inc., when the unit cooler, unit heater, and automatic valve business of Schwitzer-Cummins was purchased by Grinnell. Mr. Carraway has been unusually successful in the design and development of unit coolers and automatic equipment and is inventor of the Carraway automatic packless valve.

L. E. Underwood (A'03, M'13) who has been serving the General Electric Company at Lynn, Mass., as managing engineer of the stationary motor engineering department now has been appointed manager of the Pittsfield (Mass.) works. Mr. Underwood initiated his service in the stationary motor engineering department in 1899; was made chief engineer in 1915, and in 1927 managing engineer of the consolidated motor department in charge of engineering and manufacturing.

J. E. H. Stevenot (A'13, M'17) vice-president and general manager of the Philippine Long Distance Telephone Company, Manila, P. I., by executive orders issued by Governor-General Theodore Roosevelt under date of July 14, 1932, was made a member of a special committee on coordination of electrical communications in the Philippine Islands. This committee will meet at least once every month and submit its report to the Secretary of Commerce and Communications.

C. S. Lumley (A'23, M'29) who was electrical engineer for Smith, Hinchman and Grylls, Detroit, Mich., recently removed to Brookline, Mass., to become executive engineer of the Longwood Towers Corporation. Mr. Lumley has been with the Detroit interests, in charge of the municipal power plant project for the past 6 years; he also was chairman of the Institute's Detroit-Ann Arbor Section and a member of its membership and meetings and papers committees.

G. C. Neff (M'16) vice-president of the Wisconsin Power and Light Company, succeeds M. J. Insull (A'99) as president of the Middle West Utilities Company, Chicago, Ill., according to information recently made public. Mr. Neff has been chief operating executive of the Wisconsin Light and Power Company for several years. He has been active in the National Electric Light Association and in the promotion of rural electrification.

J. M. Barry (A'11) heretofore vice-president in charge of operation for the Alabama Power Company, Birmingham, Ala., recently succeeded to the office of vice-president and general manager. He has been with the company since 1923, when he became manager of its southern division; thereafter he was made manager of retail operation, and in May 1927 he took up his duties as vice-president in charge of operation.

C. W. Fick (A'16, M'25) who has been serving the General Electric Company's East Central district at Cleveland, Ohio, as assistant district engineer, effective October 1, 1932, became district engineer, succeeding W. S. Culver (A'28), retired. Mr. Fick prior to becoming assistant to Mr. Culver was northwestern engineer for the General Electric Company at Portland, Ore.

C. W. Adams (A'20) formerly with the United States Graphite Company of Saginaw, Mich., became affiliated on September 15, 1931, with the Speer Carbon Company of St. Marys, Pa., in the capacity of sales and consulting engineer at Saginaw, Mich. (Electrical Engineering for August 1932, p. 603, erroneously stated Mr. Adam's position and address.)

W. S. Gifford (A'16) president of the American Telephone and Telegraph Company, New York, N. Y., under date of August 5, 1932, withdrew from his work as active director of the President's organization on unemployment relief at Washington, D. C., and will again devote his full time to the office of president of his company.

J. E. E. Royer (A'15) who recently became vice-president as well as general manager of the Washington Water Power Company (Electrical Engineering, July 1932, p. 530) at a recent meeting of the Northwest Electric Light and Power Association was elected president of that organization.

Gerald Deakin (A'07, M'13) formerly vice-president and European technical director of the International Standard Electric Corporation at London, has returned to New York City to become technical director in charge of manufacturing and laboratory companies of the International Telephone and Telegraph Corporation.

E. H. Pemberton (A'32) who in the spring of 1931 was graduated from the General Electric Company's general course consisting of higher studies in electrical engineering and principles of business and management, now is teaching mathematics and physics at the Las Animas High School, Las Animas, Colo.

J. J. Albright, Jr. (A'21) previously manager of the power distribution central division of the Niagara Hudson Power Corporation, and more recently with the Niagara Lockport and Ontario Power Company at Syracuse, N. Y., now has joined the Syracuse Lighting Company of that city.

P. M. Downing (A'98, M'08) first vice-president and general manager of the Pacific Gas and Electric Company, San Francisco, Calif., recently was appointed chairman of the national sales section, an outgrowth of the former commercial section, of the National Electric Light Association.

Albert Brunt (A'14) who for some time has been director of the Societa per Construtioni Elektromechaniele di Saronno, Saronno, Italy, recently returned to Holland where he graduated from the Delft University in 1906, to become export manager of the Werkspoor, at Amsterdam.

Dean Harvey (A'04, M'13) has been chosen by The American Society for Testing Materials to serve as its chairman of committee B-4 on electrical heating, electrical resistance and electric furnace alloys. He also is vice-chairman of its committee D-9 on electrical insulating materials.

Alex Dow (A'93, F'13) president of the Detroit Edison Company, and a past-president of The American Society of Mechanical Engineers, has been appointed chief of the Detroit Ordnance District, a most important locality in Ordnance industrial procurement organization.

Thomas Spooner (A'12, F'29) manager of the central division research laboratories of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., recently became chairman of the American Society for Testing Materials committee A-6 on magnetic properties.

H. S. Vassar (A'06, M'18) laboratory engineer of the Public Service Electric and Gas Company, Newark, N. J., recently was made a member of the executive committee of The American Society for Testing Materials. His history with his present company dates from the year 1903.

H. V. Dobson (A'28) city electrical inspector for Santa Barbara, Calif., was chosen to serve as chairman of the committee in charge of arrangements for the annual convention of the International Association of Electrical Inspectors held in Santa Barbara September 12–14, 1932.

M. V. Watson (A'07) vice-president and general manager of the West Coast Power Company, Portland, Ore., at a recent meeting of the North West Electric Light and Power Association was elected a member-at-large of the executive committee to represent utilities.

A. S. Moody (A'09) northwestern manager of the General Electric Company, Portland, Ore., was elected a member-at-large on the executive committee of the Northwest Electric Light and Power Association, in Portland, Ore., to represent the manufacturers.

C. W. Bates (A'08, M'13) who for the past year or so has been in the research department of Leeds and Northrup Company, Philadelphia, Pa., in August 1932 became a member of the technical staff of The Franklin Institute Museum in that city.

A. B. Day (M'16) president and general manager of the Los Angeles Gas and Electric Corporation, Los Angeles, Calif., is a member of the recently appointed executive committee of the Pacific Coast division of the National Electric Light Association.

H. L. Curtis (A'21, F'26) principal physicist of the United States Bureau of Standards, Washington, D. C., recently assumed the chairmanship of the American Society for Testing Materials committee D-9 on electrical insulating materials.

L. T. Merwin (A'10) vice-president and general manager of the Northwestern Electric Company, Portland, Ore., was named vice-president of the Northwest Electric Light and Power Association at the executive meeting July 30, 1932.

Frederick Aemmer (A'27) who has been serving the New York Edison Company, New York, N. Y., as assistant engineer, recently was made operating manager of Kraftwerke, Oberhasli Power Company, Innertkirchen, Switzerland.

E. W. Feller (A'27) who has been in the operating department of the Pennsylvania Water and Power Company at Holtwood, Pa., has gone to Safe Harbor, Pa., to join the operating department of the Safe Harbor Water Power Corporation.

A. S. Goldman (A'28) who was formerly purchasing agent for the People's Light and Power Corporation, New York, N. Y., recently was made division manager of the California Public Service Company, at Fort Bragg, Calif.

R. W. MacGregor (A'30) who at one time was affiliated with the International General Electric Company, at Schenectady, N. Y., now is in the commercial department of the Winters National Bank and Trust Company, Dayton, Ohio.

Tom Hairston (A'30) who has been associated with the Public Utilities Commission of the District of Columbia, Washington, D. C., recently accepted a position with the Gustav Hirsch organization of Columbus, Ohio.

H. E. Dexter (A'14, M'17) who for some years has been assistant general commercial manager of the Central Hudson Gas and Electric Company, Poughkeepsie, N. Y., recently appointed as its general commercial manager.

H. K. Munroe (M'17) who was vice-president of the Continental Pipe Manufacturing Company, Seattle, Wash., now is vice-president of the American Plumbing and Steam Supply Company, Tacoma, Wash.

R. F. Pack (A'11, M'12) president of the Northern States Power Company, Minneapolis, Minn., has received appointment to chairman of the rehabilitation committee of the Ninth Federal Reserve District.

H. L. Paulding (A'31) who for some time has been interested in the development of printing telegraph apparatus, recently became electrical engineer of Dow, Jones and Company, Inc., New York, N. Y.

E. A. Wagner (A'08, F'27) has retired from the office of manager of the General Electric Company's Pittsfield works, as recently announced through company channels.

L. B. Bender (A'20, M'27) major of the Signal Corps, U.S. Army, Army War College, Washington, D. C., has been transferred to Fort Hayes, Columbus, Ohio.

J. T. Danko (A'31) has removed from McKeesport, Pa., to become instructor in mathematics and electricity at the Aliquippa (Pa.) high school.

R. A. Menendez (A'31) recently became assistant to the electrical engineer of the Harnischfeger Corporation, operating in the city of Milwaukee, Wis.

# Obituary

Magnus Washington Alexander (A'12, M'14) for the past 16 years president of the National Industrial Conference Board, Inc., New York, N. Y., died at his home in New York City on September 10, 1932, of heart attack. He was 62 years of age. Doctor Alexander was a native of New York City, but his general education was acquired in Vienna, Austria, first attending gymnasium there and later a college of mechanical engineering and mining academy for metallurgical engineering. In 1894 he joined the Weston Electrical Instrument Company, Newark, N. J., as draftsman, changing the following year to become draftsman and section chief draftsman on d-c motors and generators, and transformers for the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. In 1899 he removed to Chicago to become chief draftsman for the Siemens Halske Electric Company for one year, after which he joined the General Electric Company, West Lynn, Mass., first as engineer in charge of the drawing office for 8 years and then on economic and executive work, including educational activities. His service with the General Electric Company extended over a period of 18 years. In 1918 he was made engineer on economic issues in a consulting capacity. In 1916 he helped to organize the National Industrial Conference Board, devoted to industrial planning and research, and by 1919 he was giving the major portion of his time to its development. In 1920 the board moved its offices from Boston, Mass., to New York City, but during a portion of the 4 years just prior to his return to New York, Mr. Alexander was prominent also as chairman of the Massachusetts Commission on Old Age, Annuities and Pensions and as a member of the Massachusetts Commission on Compensation for Industrial Accidents. As the scope of the industrial conference board broadened, Mr. Alexander more and more assumed the rôle of spokesman for some of the greatest industries of the nation. In Washington in 1919 he opposed the principle of collective bargaining between capital and labor. In 1918 Mr. Alexander opposed the circulation of a school book called "Lessons in Community and Private Life" the foreword of which was written by President Wilson, the basis of his opposition being that it taught the children to favor social insurance, labor unionism, and governmental control of private activities. In November of 1930 Mr. Alexander criticized the retailers for not having cut their prices, stating that "when retail prices have reached a sufficiently low level and not sooner will there be a distinct inducement for the public to buy." Last April, in addressing the graduating class of the General Society of Mechanics and Tradesmen, he said, "When all is said and done the conclusion would seem to be justified that the basic cause of the recent colossal collapse was overindulgence in the expansion of industrial plants and equipment, in production, in stimulation of production by excessive advertising, high-pressure salesmanship and instalment selling; overindulgence in spending, and overindulgence in speculation."

**Grover Cleveland Sutton** (A'11) a member of the Institute's Spokane Section and at the time of his death vice-president of the General Machinery Company, Spokane, Wash., died in that city August 2, 1932. Mr. Sutton was a native of Worton, Md.; he studied electrical engineering first by a correspondence school course; then attended Washington College at Chestertown, Md., from which he won his A.B. degree, and still later studying at Carnegie Institute of Technology, then known as the Carnegie Technical Schools. His first commercial affiliation was as chief engineer of the Chestertown Electric Light and Power Company, Chestertown, Md. This was during his last 2 years at college. In 1907 he became an engineering apprentice with the Westinghouse Electric and Manufacturing Company, at Pittsburgh, Pa., and 2 years later was sent to Spokane, Wash., as salesman for this company. The years 1910–12 were spent as erecting and operating engineer in saw mill electrification, after which he became purchasing agent for saw mill, logging, and all related operations. In this capacity he was responsible for all engineering in connection with an extensive logging and lumber manufacturing business, advising as to the necessity of purchase on all matters coming within his jurisdiction.

**Charles Shirley McGill** (A'21) who has been serving the Delaware Power and Light Company of Wilmington, Del., as plant superintendent, died the latter part of August 1932. Born at Leesburg, Loudoun County, Va., Mr. McGill attended the Leesburg Academy, and later the East High School in Washington, D. C. He took a private course in higher mathematics under Prof. Brantz Rossell at Johns Hopkins University, and further studied mathematics and electrical engineering by correspondence. In 1895 at the age of 18 he became a shop apprentice with the Metropolitan Railway Company, Washington, D. C., remaining there until 1897 when he was engaged as a switchboard operator by the Columbus Edison Company at Columbus, Ohio. In 1900 he left Columbus to accept work as apprentice and salesman of the Westinghouse Electric and Manufacturing Company, to operate both at Pittsburgh, Pa., and Baltimore, Md. Four years later the Houston Coal and Coke Company of Elkhorn, W. Va., made him its chief electrician; he simultaneously performed like duties for the Thacker Coal and Coke Company, at Thacker, W. Va., installing and placing in operation power house and mine haulage for these 2 companies. In 1907 the Western Electric Company, Cincinnati, Ohio, made him assistant sales manager, but in 1909 he changed to become sales engineer for Allis-Chalmers Manufacturing Company, Cleveland, Ohio. Returning again to Cincinnati in 1911 he became branch manager of the Crocker-Wheeler Company, 4 years later to return to the Allis-Chalmers Manufacturing Company, this time at Huntington, W. Va., as branch manager. In 1916 he took up power engineering with the Wilmington and Philadelphia Traction Company, and a year later was advanced to the office of electrical superintendent.

**Max Kushlan** (A'28) electrical squad chief of the New England Power Construction Company, Mattapan, Mass., died in Boston, Mass., August 1932, following an operation. He was born at Minsk, Russia, but came to the United States at an early age and attended the English High School at Boston, Mass., Tufts College, at Medford, Mass., and the Massachusetts Institute of Technology, Cambridge, Mass., from which latter institution he received his S.B. degree. From 1909 to 1910 he was a cable tester for the Boston Elevated Railway Company; then he joined Stone and Webster, Inc., as a draftsman remaining with this organization until 1912 when he went as assistant mechanical engineer to the Goldschmidt Detinning Company, East Chicago, Ind. Remaining there until 1913, he joined Sargent and Lundy, Chicago, Ill., as electrical draftsman; 2 years later he became engineering draftsman for the City of Chicago. In 1916 his title was changed to designing engineer, city of Chicago, and he was made assistant to the head of the division of bridges, in responsible charge of design of mechanical and electrical equipment for bascule bridges, his work including reports and specifications. The year 1920 found him electrical engineer of the Bascule Bridge Company, Chicago, directing electrical design work in the office and supervising the work in the field. He also represented his firm at conferences with clients. In 1921 he established his own business as engineer and contractor, but the following year joined the Brooklyn Edison Company, Brooklyn, N. Y., as electrical checker, a service which he continued until 1923, when Stone and Webster, Inc., made him its electrical designer in responsible charge supervising and checking electrical drawings and estimates in connection with power station design. Mr. Kushlan was the author of "The Gas Motor" and "Freehand Drawing," and contributed articles to technical magazines.

**James Andrew Shepard** (A'13) assistant general manager of the Roan Antelope Copper Mines, Ltd., Luanshya, Northern Rhodesia, died July 13, 1932, following a hospital stay of some 10 days. He was born in Deming, New Mexico, in 1889 and was graduated as an electrical engineer from the Rose Polytechnic Institute, Terre Haute, Ind. From there he entered the electrical department of the Detroit Copper Mining Company, Morenci, Ariz. Upon leaving Morenci, Mr. Shepard served the Public Utilities Companies in Deming and Tucson, Ariz., and was later appointed manager of the Bisbee-Naco Water Company. In 1926 he joined the Phelps Dodge Corporation at its Copper Queens branch at Bisbee, Ariz., first as assistant general manager, and when the general superintendent was transferred to Northern Rhodesia, Mr. Shepard took over his duties. In 1929 Mr. Shepard went with the Roan Antelope Copper Mines, Ltd., as assistant general manager, where he was greatly respected by every one with whom he came in contact.

# Local Meetings

## Future Section Meetings

**Dallas**

October 17—Vibration of Electrical Conductors, by R. A. Monroe, Aluminum Co. of America. Illus.

**Lehigh Valley**

October 14—Electrons at Work and Play, by Phillips Thomas, Research Engr., Westinghouse Elec. & Mfg. Co. Meeting to be held at the Traylor Hotel, Allentown, Pa.

**New York**

October 14—Opening meeting of power group; meeting devoted to "Serving the Electric Consumer." The utility's problem will be presented by H. R. Searing, The New York Edison and United Electric Light and Power Companies, while the contractor's problem will be discussed by Allan Coggeshall, President, Hatzel and Buehler, Inc. Discussion of items such as demand factor, power factor, voltage requirements, motor starting currents, and attendant costs will illustrate that each of the 2 agencies, utility and contractors, must work with an understanding and appreciation of the functions and problems of the other, in order that service of a high standard may be rendered. The meeting will convene at 7:30 p.m., and will be adjourned promptly at 9:30. Non-members are welcome. Discussion is open to all. The location will be Room 1, Fifth Floor, Engineering Societies Building.

**Pittsfield**

November 1—Japan, China, and the White Man, by Upton Close.

November 15—Air Conditioning—Perfect Weather in Your Home 365 Days a Year.

## Past Section Meetings

**Mexico**

Vacuum Tubes and Applications to Industry, by C. Santacruz, Genl. Elec. Co. Illus. Dinner. Aug. 26. Att. 42.

**Milwaukee**

Public Works, by Maj.-Genl. Lytle Brown, U.S. Army. Joint meeting with the Engrs. Soc. of Milwaukee.

**Pittsfield**

Excursion. Aug. 31. Att. 227.

**Spokane**

Adventures in Science, by E. L. Manning, Genl. Elec. Co. July 1. Att. 450.

**Toledo**

Discussion of activities for coming year. Sept. 9. Att. 27.

## Past Branch Meetings

**University of California**

Dr. L. E. Reukema, counselor, reported on the summer convention held at Cleveland, O. Dr. L. F. Fuller outlined changes and activities in the elec. engg. dept. during the coming year. Motion pictures. Aug. 24. Att. 70.

**Drexel Institute**

The Therapeutic Value of X-Rays, by Edward Cliver, student. Aug. 16. Att. 7.

# Employment Notes

## Of the Engineering Societies Employment Service

## Men Available

### Construction

E.E., grad., 35, married; 19 years experience as electrician, construction foreman, substation operator. Elec. welding experiments; 3 yr. utility, drafting and engg.; $3^{1}/_{2}$ yr. Western Elec. mech. and elec. designs. Wiring diagrams and genl. industrial plant construction. Best references. Scandinavian languages. D-1393.

GRAD. E.E., 29; 5 yr. supervisory construction, design, estimating, and field engg. experience on super-pwr. plants and substations; 4 yr. industrial pwr. plant operation, elec. construction and maintenance experience; ry. electrification construction experience. C-4428.

PRACTICAL ELEC. CONSTR. CHIEF, 32, single, 14 yr. experience in construction also maintenance work. Last 4 yr. in Latin America. Can speak Spanish and German fairly well. Available immediately. Location, immaterial. C-2101.

YALE GRAD., 1927, B.S. in E.E., desires engg. position or teaching, $1^{1}/_{2}$ yr. experience testing ry. ltg. equip.; $3^{1}/_{2}$ yr. design and application of outside plant hardware in natl. utility. Also experience in operation of small pwr. plant. Location preferred East. D-1305.

ELEC. CONSTR. ENGR., with 10 yr. practical experience in elec. constr. of new and old bldgs., including estimating, field engg. and designing. Have had complete charge of elec. constr. on many bldgs. in N. Y. City and can furnish the best of references. Available at once. A-850.

### Consulting

CONS. ENGR., Grad. E.E., 31, with Am. and S. Am. experience in distribution and transmission design and construction, appraisals, meters, testing, purchases and stores, and pwr. sales. Desires opening in consulting office. Location, immaterial and salary secondary. D-1383.

### Design and Development

E.E., 31, single, Am., 4 yr. experience in design of sound reproducing equip., 5 yr. of practical ry. signaling work in field and office, part in foreign countries, speaks and writes German, Spanish and French, wishes engineer's position in the elec-mech. field, location anywhere. Available immediately. C-5056.

SWITCHBOARD DESIGNER, 29, married, 6 yr. experience in design of a-c. and d-c. pwr. plant switchboards, motor controls, wiring schemes, switchboard: estimating, sales, erection supervision and engg. Also 3 yr. experience on manual and automatic tel. switchboards. Desires position as designer, estimator or sales engr. Location in East preferred. D-1423.

ELEC. DESIGNER, 30, married, 5 yr. experience with telegraph company, competent draftsman; speaks Spanish correctly and fluently. Will accept domestic or foreign location. Available at once. D-1442.

E.E., 10 yr. experience. B.S. Worcester P. I. 1922. E.E. 1924. A'25, M'32, Section chm. '32 A.I.E.E. Single, 32, 8 yr. experience Westinghouse transformers and auxiliaries, 2 yr. executive experience. Possesses inventive and natural ability, personality and adaptability. Capable of assuming responsibility. Location, immaterial, New England preferred. D-1443.

ELEC. DESIGNER, 32, married, equivalent of col. education, best of references, 14 yr. experience in design of hydroelectric and steam pwr. plants, auto. ry., high and low tension substations and low tension network systems. Available at once. Location, immaterial. B-8628.

E.E. GRAD., 30, married 5 yr. with Westinghouse design and application of protective relays, 3 yr. with utility as switchboard designer and kindred work. Desires position with utility or mfr. Location preferred, Southwest, but anywhere acceptable. Available immediately. D-1476.

B.S. in E.E. 1929. 34 months of Westinghouse test including industrial motors, large generating apparatus and ry. motors. Interested in securing a position with a large industrial concern or utility. Location vicinity of New York. Available immediately. D-1455.

### Executives

E.E., univ. grad., 4 yr. experience, drafting, design, construction and engg. of modern hydro and steam pwr. plants, substations and ry. electrification, $5^{1}/_{2}$ yr. with leading mfg. concern in engg. of automatic and manual switchgear equip. Foreign languages. Desires position with utility, engg., mfg. or ry. concern. Location, immaterial. B-7938.

ELEC. AND ILLUM. ENGR., Mem. A.I.E.E., I.E.S., 26 yr. experience commercial and industrial wiring and construction. Would like to connect with progressive contractor; estimating, engg., supervising, soliciting and selling work on quality rather than on price. Moderate salary to grow with business. Any location. C-8460.

E.E. GRAD., 29, married, 7 yr. broad experience, powerhouse, substation and transmission line design; major apparatus application, cost estimate, and equipment specifications. Excellent references. Desires connection with holding company, utility or mfr. D-678.

CHIEF ENGR., 42, married, practical, aggressive executive, with 20 yr. experience in design, development, production, sales and application of elec. material handling and factory equip. Available now. A-445.

ASSOC. A.I.E.E., B.E.E., '21, 39, single, $2^{1}/_{2}$ yr. additional study civ. engr.; 3 yr. steam R.R. valuation, elec. and mech. branch; 11 yr. track dept., large st. ry. property. Field engr., track supervisor and asst. to supt. maintenance; 5 yr. estimator track constr. semi-working knowledge spec. trackwork design. Location optional. D-1392.

TO AM. ENGG. CONCERNS operating in Spanish speaking countries—B.S. in E.E., 1929, single; 3 yr. genl. engg. experience, including erecting and testing pwr. equip.; conducting illum. and voltage surveys. Can speak English and Spanish equally well. Tech., administrative type of individual. D-1462.

E.E., M.E., 22-yr. experience, designing, constr. pwr. plants, substations, transmission, distribution systems, and industrial plants. Three yr. charge purchasing engg. equip., foreign interests; 3 yr. exec. experience charge engg. dept. large utility. English, German, Russian, Armenian, Turkish languages. Available immediately. D-84.

E.E., 34, 10 yr. experience covering design, cost estimating and equip. specifications of pwr. plants, copper refineries, indoor and outdoor substations, transmission lines and industrial work. Also 1 yr. experience as asst. research engr. with cable co. C-5478.

E.E., grad., 34, single; 7 yr. experience with utilities, estimating and designing transmission lines, substations and distribution systems; also reports and valuation of elec. properties. Speaks and reads German. Available immediately. Location, immaterial. B-8649.

ENGR. EXEC., M.E., M. I. T. grad.; 17 yr. broad experience in mfg. design and layout of plants; maintenance, mgmt. of machine shops, foundries, woodworking plants and other industrial plants. Purchasing. Traveled as mfrs. representative abroad. Knowledge of Russian, German. B-2589.

E.E. also B.S. in M.E. and C.E., 37; married. Splendid 15-yr. record of engg. accomplishments including design, development, application, supervision and exec. charge. Best reference. Desires opportunity where education and experience will prove valuable. Correspondence invited for more particulars. D-1494.

EXEC., univ. grad., 16 yr. experience in engg., mfg. and sales. Will consider proposition on salary or salary and commission basis. Location any place in U. S. A., although New York or vicinity preferred. Available at once. Prepared to travel. A-3946.

GRAD. ELEC., HYDROELEC. ENGR., 31, married, 2 yr. experience marine elec. installation; 8 yr. design, construction of steam, hydro pwr. plants, outdoor, indoor substations, transmission, distribution lines, wiring diag., indus. plants, office bldg., estimating, preparation of specifications. Desires position, utility, cons. engg. firm, industrial concern. Consider any location. Available immediately. D-212.

### Inspection

ELEC. GRAD., 38, single; 6 yr. experience factory testing—W. E. & M. Co., E. Pittsburgh, Pa.; 1 yr. steel co. installing and testing elec. equip. Six months factory inspection of transformers, $2^{1}/_{2}$ yr. genl. inspection of elec. equip. with insurance co. Good reference. Available immediately. Any location. D-1461.

### Instruction

E.E. GRAD., 1929; 3 yr. instructor of economics of engg. Grad. work in economics and business administration. Desires to teach economics and related subjects to engrs. or to get into any kind of engg. mgmt. Available immediately. Location, immaterial. D-1405.

PHYSICIST, 49, married, Ph.D.; 7 yr. univ. teaching experience, Yale, U. of Ill.; 1 yr. study Rutherford, Eng.; 15 yr. experience, directing, carrying on research in heat transmission and phases elec. and mech. lines 2 large industrial concerns. Present position being discontinued. Desires position of responsibility, univ. teaching or industrial research. D-1366.

### Junior Engineers

E.E. GRAD. with honors, 1932, Ala. P. I., 23, single. Speaks fluently Greek and English. Desires experience and is willing to work. Worked way through col. Excellent references. Interested in sales work. Glad to hear from you. D-1384.

ELEC. INSTRUMENTS, 6 yr. mfg. experience pyrometer indicators, controllers and recorders, specialized on galvanometer construction. B.S. 1922 chem. engg., Pennsylvania St. Col. At Columbia 1931–1932 studying elec. and physics. Single, 31. Any line elec. mfg., testing, etc. Location, New York or East. D-1382.

## ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
San Francisco

205 West Wacker Drive
Chicago

31 West 39th St.
New York

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

**Men Available.**—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

**Opportunities.**—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

**Voluntary Contributions.**—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

**Answers to Announcements.**—Address the key number indicated in each case and mail to the New York office, with an extra three-cent stamp enclosed for forwarding.

GRAD. E.E., Rensselaer P. I., 1932; 22; single. Desires any kind of work in the elec. field. Location, immaterial. Available at onec. D-1397.

MOVING PICTURE SOUND staff position desired by Carnegie Tech grad. (1932). Prefers position with an opportunity for research in the transmission of moving pictures, 8 yr. experience as moving picture operator (present employment). Experienced in taking pictures and developing films. Married, 26. D-1419.

B.S. in E.E., 1932, Mich. Col. of Min. and Tech., married, 23, desires position in any engg. field. Good scholastic record. Tau Beta Pi. Salary and location, immaterial. Available at once. D-1418.

E.E. GRAD., 1932, single, B.S. VPI, prepared to learn and specialize in any line of E.E. work. Excellent character. Little experience in conduit work. Virginia present address. D-1420.

B.E.E., 1932, U. of Minn., 21, single. Two summers constr., Northwestern Bell Tel. Co. Major in communications. Special investigation of microphones. Desires any position. Not afraid of hard work and satisfied with decent living wage. Location, immaterial. Good scholastic record and character references. Good physical condition. Available immediately. D-1425.

1930 GRAD. in E.E., B.S. from North Car. State College, 25, single. 2$^1/_2$ yr. experience in installation of motors and bldg. wiring, 2 yr. with constr. co. in inspecting and testing pwr. transformers and other equip. for substations. Location, East. Available at once. D-1431.

E.E. GRAD., B.S. in E.E., U. of Ill., 1932, 23, single. Ten months long distance telephone test A. T. & T.; 2 months Ill. Bell Tel. Co. Some knowledge of motion picture sound equip. Familiar with vacuum tubes and their applications. Available at once. Location, immaterial. D-1108.

E. E. GRAD., U. of Ill., 1932, single. Fifteen months Westinghouse test. One yr. teaching pub. sch. Desires permanent connection. Available at once. Starting salary and location, immaterial. D-1446.

E.E. GRAD., M.S. in E.E., Iowa St. Col., 1932, 22, single. Best of character and willing to start at the bottom and work up. Short experience in tech. writing. Desires any position that will pay a living wage. Available immediately. D-1276.

E.E. GRAD., B.S. in E.E., Drexel Inst., 1932, cooperative course, 23, single. Nine months in plant dept. of N. J. Bell Tel. Co.; 6 months pwr. plant testing. Desires engg. or teaching position. Location in East preferred. References upon request. Available immediately. D-1466.

E.E. GRAD., U. of Minn., 1930, 25, single. Two yr. experience with Northern States Pwr. Co., including 1 yr. training course and 1 yr. distribution engg. Available immediately. Location, immaterial. D-1477.

E.E. GRAD., 24, single. Broad education and experience, good record; 4 yr. Bell system, 1 yr. elec. mfg. and development. Interested appraisal, aeronautics, air conditioning, refrigerating, utility, mech. engg., or other work. Also experienced secretarial, traffic and chem. mfg. lines. Excellent references. Location and salary, immaterial. D-1475.

JR. ENGR., S.B., 1926 M. I. T., single, 28; 5 yr. experience with large company on design, engg., and constr. on pwr. plants, substation and indoor plants. Desires connection with constr., util., or holding co. Available immediately. D-1487.

B.S. in E.E. CCNY, Tech. high school, 2 yr. radio experience, 21. Desires position as asst., sound, radio work, etc. Moderate salary, references. D-1488.

B.E.E. Northeastern Univ., 1931. Cooperative course, single, 24. Desires position with utility or engg. firm. About 1$^1/_2$ yr. on substation and switching yard work, also some maintenance work. Available at once. B-41.

TECH. WRITER, Cornell A.B. and E.E., 23, single. Special training in writing clear concise English fits him to prepare reports, specifications, instruction sheets, publicity, etc. Experienced in pwr., radio, and communications fields. Salary secondary to opportunity in this particular work. Location, immaterial. Available at once. D-1221.

E.E. GRAD., 1931, cooperative course, 23, single. Broad general experience. One yr. with radio concern, 8 months on registers. Literary ability. Salary immaterial. Location, East preferred. Available immediately. D-1414.

YOUNG ENGR., I.E.E. grad. 1930, desires position in jr. engg. work. Has had 4 yr. varied elec. experience including lt., heat and pwr. wiring and automatic relay (telephone type) equip. maintenance. Aggressive, capable and not afraid of hard work. Salary and location, secondary. D-1465.

RENSSELAER P. I. GRAD., elec. engr., 23, single. Wishes position in any elec. field. Has worked 1 summer with Pub. Serv. of N. J. and 1 summer with G. E. Co. in N. Y. City shop. Available at once. D-1158.

E.E., 21, B.S. in E.E.; 1 yr. experience in elec. motor repair and constr. Interested in elec. pwr. engg. Location, immaterial. Available immediately. D-1485.

E.E. GRAD., Northeastern Univ. 1932, single, 21; 1 yr. transformer testing. Good references. Prefer position with utility, but will consider anything. Salary and location, secondary. Available immediately. D-1498.

GRAD.; E.E. 1929. G. E. test experience including work in radio and vacuum tube engg. depts. and with all types of elec. mchy. Utility elec. rate analysis experience covering pwr. companies in all states. Received M.S. in June 1932. Desires an engg. opportunity. D-1036.

### Maintenance and Operation

CONSTR. AND MAINTENANCE SUPT., 37, married. Grad. E.E.; 13 yr. experience in the utility field, particularly in engg., constr. and maintenance of distribution and transmission substations. Desires position with large utility with responsibility for the constr., operation and maintenance of substations. B-2885.

E.E., grad., 1929, 26, married; 1 yr. Westinghouse grad. student course and 2$^1/_2$ yr. of elec. test. Desires position as maintenance, installation or operating engr. Location, immaterial. Available with 2 weeks notice. C-7431.

E.E., 18 yr. experience on design, construction, maintenance, operating methods and problems, desires position with pwr. co. or firm using elec. driven equip. Univ. grad. B-1923.

### Research

Ph.D. in E.E. Calif. Inst. Tech. '32. 2 yr. practical experience as electrician; 5 yr. elec. drafting, teaching and research. Research dealt with measurement of ltg. currents and especially with elec. dehydration of petroleum. Desires research position where experience and training will be useful. Single, 28. Location, immaterial. D-1350.

E.E. 1930, with 2 yr. research work, post-grad. study and excellent scholastic record, desires tech. work, preferably mathematical. Location, vicinity of N. Y. City preferred. D-1183.

E.E., Brown, 1921; Columbia Univ.; 32, single; 5 yr. Western Elec. Co., installation, test, design, automatic telephone equip.; 6 yr. Bell Telephone lab., design, development, research, electromagnetic relays, vacuum tube circuits for cable and radio. Interested; consulting, development, research on above and allied fields. Languages, French, German. Prefers New York. C-1047.

RESEARCH ENGR., specialties, photoelectric color-matching equip.; light sources. B-7066.

TESTING AND RESEARCH ENGR., Phys. tests of materials, metallography, X-ray and spectroscopic structure analysis. Well versed in physics. Languages: English, German, French. Location and salary of secondary importance to opportunities. C-6994.

DEVELOPMENT ENGR., 26, single, E.E. and M.S., high scholastic rating; 3 yr. G. E. Co. research, test and field engg., 2 yr. development of pwr. plant equip. for telephone offices. Location, immaterial. Best of references. Available now. D-1219.

ENGR., 15 yr. automatic printing telegraph development, including 7 yr. with mfr., desires situation, preferably East. Salary consistent with responsibilities. Broad experience with fine high-speed mchy.; sound knowledge of circuits and circuit theory; can handle men; languages, French, Spanish. Available now. D-1459.

B.S. in E.E., Harvard 1924, G. E. test and 5 yr. in research lab. in Schenectady. Research work involving elec. arcs or switching phenomena preferred, but open for other engg. work. Available immediately. D-1486.

E.E. GRAD., 23, Sc.M. M. I. T., Harvard '28; Sc.D. M. I. T. June '32; single, 38; 9 yr. practical experience pwr., business and communication engg.; 2 yr. testing course. Valuable contribution to net-work synthesis. Speaks Swedish, English, German; reading knowledge French. Desires position, well known organization. Available. Location, immaterial. D-747.

### Sales

SALES ENGR. OR MFG. AGT., grad. E.E., 32. Over 5 yr. with utility in constr. maintenance and design; over 3 yr. as sales engr. for elec. mfr. including about 3 yr. as jr. exec. Location immaterial for salary position. Pittsburgh headquarters as mfg. agent. D-745.

B.S., E.E., U. of Ill., 1930, single; 2 summers A. T. & T. Co. Student engr. 6 months, Elec. Mach. Mfg. Co. Employed since Jan. 1931, special committee, stresses in R.R. tracks, asst. test engr., U. of Ill. Interested, pwr., a-c. mchy. Experience, sales work. Available month's notice. Salary, promotion primary. Location, secondary. D-1439.

DISTRICT SALES MGR. OR MFRS. AGT.: experienced engg. representative, desires connection with high grade co. that has line of industrial or utility equip. Eastern location preferred. B-4067.

B.S. in E.E., PROF. ENGR., N. J., 34, married. Steel corp. sales engr. 3 yr. contacting archts., engrs., N. Y., N. J.; heat and sound insulation sales engr., 4 yr. contacting architects, engrs., heating trade, plus job supervision; storage battery automotive elec. sales and service 5 yr.; inventive ability and experience. C-75.

# Membership

## Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the acting national secretary before Oct. 31, 1932.

Baldwin, J. G., Montreal Lt., Heat & Pwr. Consolidated, Montreal, Quebec, Can.
Basinger, C. B., Wind Turbine Co., West Chester, Pa.
Fetterman, R. E., 340 Wilson Ave., Port Clinton, Ohio.
Fracker, H. E., Bell Tel. Lab., N. Y. City.
Greene, A. B. (Member), Florida R. R. Commission, Tallahassee.
Harris, R. S., c/o Lowell Observatory Flagstaff, Ariz.
Hedrick, W. A. (Member), 422 College Ave., N. E., Grand Rapids, Mich.
Hess, W. F., 25 Hawthorne Ave., Troy, N. Y.
Litchfield, N. (Member), c/o Gibbs & Hill, N. Y. City.
Niedurny, W. J., c/o L. E. Myers Co., N. Y. City.
Pitman, J. B., 3110 Lincoln Ave., Alameda, Calif.
Sine, E. R., Box 226, Nassau, N. Y.
Whalley, R., Pacific Elec. Mfg. Corp., San Francisco, Calif.
13 Domestic

### Foreign

Alizo, C., Antonio Cia. Annma., Planta Elec. de Valera, Est. Trujillo, Venezuela, S. A.
Banton, F. B. (Member), Cia Colombiana de Electricidad, Barranquilla, Colombia, S. A.
Foulsum, W. C., 16 Bondoran Parade, Mont Albert, Melbourne, Australia.
Gibbes, G. B., Govt. Elec. Dept., St. George's, Grenada, B. W. I.
Kesavan, V. K., Pwr. Station Kottayam Travancore, So. India.
Lautier, V., 37, Sda. San Paolo, Cospicua, Malta.
Rozario, J. F. T., Pub. Wks. Dept., Madras Govt., Madras, India.
Sarda, P. M., Ratan Pole, Nagori Pole, Ahmedabad, India.
Singh, H., Simla Municipal Committee, Idgah, Simla.
Swami, T. V., Elec. Dept., Cocanada, India.
10 Foreign

# Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Adams, Albert J., 950—18th Ave., Honolulu, T. H.
Bingel, G. H., Gen. Del., City Hall P. O., N. Y. City.
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Uline, Wm. A., Northern Elec. Co., Guy & Notre Dame Sts., Montreal, Que., Can.

# Engineering Literature

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

Die ABHÄNGIGKEIT der WERKSTOFF-DÄMPFUNG von der GRÖSSE und GESCHWINDIGKEIT der FORMÄNDERUNG. (Mitteilungen des Wöhler-Instituts, Heft 11.) By E. Bankwitz. Berlin, NEM-Verlag, 1932. 53 p., illus., 8x6 in., paper, 3.60 rm.—On the behavior of metals under repeated stress. Vibration diagrams of steel, copper, brass, and aluminum, based upon careful tests, are given and the influence of speed of deformation upon the magnitude of damping and of alternating stresses upon the static properties of these materials are discussed.

ANNUAIRE des INGÉNIEURS de FRANCE, 1931. Paris, Loubat, Éditeur. 1070 p, 9x5 in., paper, no price given.—A directory including names of engineer graduates of the 12 principal engineering colleges of France, and members of the French Society of Electricians and of the Society of Civil Engineers of France; about 35,000 names and addresses.

ARCHITECTURAL ACOUSTICS. By V. O. Knudsen. New York, John Wiley & Sons, 1932. 617 p., illus., 9x6 in., cloth, $6.50. A reference for architects, builders, and others interested in design and construction of buildings, with theory and practical application of architectural acoustics clearly set forth. Essentially practical in character; it gives information upon the absorption of sound, sound insulation, properties of insulating materials and the acoustics of auditoriums and music rooms. The application of acoustics to schools, churches, theatres, and other buildings is discussed at length and liberally illustrated. A book to enable the architect and builder to meet his problems intelligently.

AVIATION and the AERODROME. By H. A. Lewis-Dale. Philadelphia, J. B. Lippincott Co., 1932. 168 p, illus., 9x6 in., cloth, $6.00.—Dealing with the question of sites and the broad aspects of the engg. problems of a more or less specialized character involved in the construction and ground equipment of aerodromes. The treatment is concise and definite, with numerous examples of plans and buildings. The author, since 1914, has been engaged in the construction of aerodromes for the British Admiralty and Air Ministry.

CARL von LINDE zum 90. GEBURTSTAG. (Deutsches Museum Abhandlungen und Berichte, Jahrgang 4, Heft 3, 1932.) Berlin, VDI-Verlag, 1932. P. 55–84, 8x6 in., paper, 1 rm.—A brief memorial celebrating the 90th birthday of the famous engineer, with an extract from his autobiography, a bibliography of his published writings, an address upon the fixation of gases of the atmosphere and a short historical account of the evolution of refrigeration.

DANA'S TEXTBOOK of MINERALOGY with an extended treatise on crystallography and physical mineralogy. By E. S. Dana. 4th ed. by W. E. Ford. New York, John Wiley & Sons, 1932. 851 p., illus., 9x6 in., cloth, $5.50.—The new edition of this well-known textbook has been brought thoroughly up to date. Essential changes include new sections upon crystal structure and investigation of it by means of X-rays; also upon the origin, mode of occurrence, and association of minerals. The section upon descriptive mineralogy fully revised and description of about 220 new species added. The last section now includes brief descriptions of all known minerals.

ELEKTROLYTE. By H. Falkenhagen. Leipzig, S. Hirzel. 1932, 346 p., illus., 10x7 in., paper, 23 rm.; bound, 24.80 rm.—An able review of the work of Faraday, Arrhenius, Lewis, van Laar, Milner, Debye, and many others who have studied the theory of electrolytes. The evolution of current theories is traced carefully and comprehensively.

Die FERROMAGNETISCHEN LEGIERUNGEN. By W. S. Messkin and A. Kussmann. Berlin, J. Springer, 1932. 418 p., illus., 10x6 in., cloth, 44.50 rm.—This book is a systematic survey of ferromagnetic metals and alloys presenting in a practical way not only the properties from a magnetic point of view, but also the influence of metallurgical treatment upon these properties. Designed to serve the metallurgist, the physicist, or chemist engaged in research work, and the electrical engineer, it opens with the theory of magnetism; then the author discusses magnetic measurements, the influence of chemical composition and physical state upon magnetic properties, magnetic analysis of metals, physical properties, permanent magnet steels, alloys for dynamos and transformers, alloys for special purposes, and the production of magnetic alloys. It is an endeavor to consider all the alloys now used industrially as well as those for prospective use.

HIGHWAY MATERIALS. By E. E. Bauer. 2 ed. New York & London, McGraw-Hill, 1932. 374 p., illus., 9x6 in., cloth, $3.50. Intended primarily as college text, to give the student a general working knowledge of the qualities of materials for various types of pavements. Besides the methods of sampling and testing, qualities and specifications of road materials and the interpretation of the results of tests are discussed. Specifications and tests of the Am. Soc. for Test. Mats. are used, this edition revised to include its latest practise.

NEGRO HOUSING. Edited by J. M. Gries and J. Ford. Washington, D. C., President's Conference on Home Building and Home Ownership, 1932. 282 p., illus., 9x6 in., cloth, $1.00.—A comprehensive, valuable report, based upon a nationwide survey of conditions. The social, economic, and financial phases of the problem are presented. The committee finds a remedy for the negro citizens inability to obtain sanitary dwellings and privacy, by providing housing acceptable to persons of low incomes through better plans of production for all housing.

SCHWINGUNGEN an FREILEITUNGSSEILEN und ihre DÄMPFUNG durch RESONANZ-SCHWINGUNGSDÄMPFER. (Mitteilungen des Wöhler-Instituts, Heft 12.) By F. Puritz. Berlin, NEM-Verlag, 1932. 67 p., illus., 8x6 in., paper, 3.60 rm.—A report giving results of experiments upon methods of reducing vibrations in electric lines and masts. Rubber dampers adjusted to the rate of vibration of the mast-wire system were found helpful.

SCIENTIFIC PRINCIPLES of PETROLEUM TECHNOLOGY. By L. Gurwitsch and H. Moore. 2 ed. New York, D. Van Nostrand Co., 1932. 572 p., illus., 9x6 in., cloth, $8.00.—In 1926 Mr. Moore published a translation of Prof. Gurwitsch's well-known book, with additions. This translation he now has revised and expanded to include especially the results of recent American research work. The book discusses the chemistry and physics of petroleum and principal products and methods of distilling and refining them from the scientific point of view without attempt to treat practical questions of technology. As a review of petroleum chemistry, this work should be a welcome addition to literature.

SMOKE: A Study of Aerial Disperse Systems. By R. Whytlaw-Gray and H. S. Patterson. London, Edward Arnold & Co., 1932. 192 p., illus., 9x6 in., cloth, 14s.—Few attempts have been made to explain the behavior of smoke in terms of general principles, or even to correlate its properties with the number, size, and nature of its constituent particles. This volume delineates the scientific study of smoke, based largely upon the last few years of investigations at Leeds. It provides a general survey of the subject, and describes methods of investigation and results obtained, pointing out further lines of research.

STRESSES in SIMPLE STRUCTURES. By L. C. Urquhart and C. E. O'Rourke. 2 ed. New York and London, McGraw-Hill, 1932. 339 p., 9x6 in., cloth, $3.50.—A textbook to set forth clearly the fundamentals of stress calculation in simple structures, without consideration of economics of design. Both analytical and graphical methods are used. A new edition, entirely rewritten, and with new chapters upon the 3-hinged arch and deflection.

TECHNISCHES WÖRTERBUCH VII (Sammlung Göschen 1050). Die wichtigsten Ausdrücke der Elektro- und Radiotechnik. Pt. 3. Deutsch-Französisch. 2 ed. By E. Krebs. Berlin and Leipzig, 1932. 187 p., 6x4 in., cloth, 2 rm.—A concise German-French dictionary of terms used in radio and telephone engineering, similar to the earlier German-English dictionary by the same author. The volume is of convenient pocket size with words well chosen for ordinary needs.

ZAHNRÄDER, Pt. 1. (Werkstattbücher, Heft 47.) By G. Karrass. Berlin, J. Springer, 1932. 60 p., illus., 9x6 in., paper, 2 rm.—A concise work on the design of gears. One of a series upon shop practise. The aim is to present the subject both scientifically and practically upon the basis of current practise and without complicated mathematics.

HOUSE DESIGN, CONSTRUCTION, AND EQUIPMENT. Edit. by J. M. Gries and J. Ford. Washington, President's Conference on Home Building and Home Ownership, 1932. 325 p., illus., 9x6 in., cloth, $1.00.—The program for raising the standard of American housing adopted December 1931 by the President's Conference on Home Building and Home Ownership has resulted in reports by experts. This one is the work of committees composed of well-known architects, engineers, and home economists from all parts of the country. Recommendations are based upon practical experience and essentials of good practise; also better coordination of effort in the building trade is discussed indicating how building costs may be lowered for the wage-earner. Much useful information for architects, builders, and prospective owners is given.

HYDROGEN IONS. By H. T. S. Britton. 2 ed. N. Y., D. Van Nostrand Co., 1932. 589 p. illus., 9x6 in., cloth, 25s.—An exhaustive, critical summary of present literature upon methods of determining the concentration of hydrogen ions, the importance of these ions in general chemistry, their rôles in industrial processes, and the value of hydrogen-ion concentration measurements for purposes of control. The discussions of the importance of hydrogen-ion concentrations in the electrodeposition of metals, in tanning, sugar manufacture, pulp and paper-making, water purification, corrosion, sewage disposal, ceramics, and flotation will be useful to engineers wishing a concise introduction to modern progress. Thoroughly revised.

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MAINTAINED as a public reference library of Engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

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Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

# Industrial Notes

**Lincoln Appoints G. E. Tenney.**—Announcement has been made by the Lincoln Electric Company, Cleveland, of the appointment of G. E. Tenney as sales manager of its Chicago district. The Chicago offices are located at 1455 West 37th Street, where a sales and service organization is maintained for all Lincoln products, including "Shield-Arc" welders, welding supplies, and "Linc-Weld" motors.

**Rapid Reversing Motors.**—The Louis Allis Company, Milwaukee, announces a new line of rapid reversing squirrel cage motors, capable of as many as sixty reversals per minute continuously without overheating. Such high rates of reversals have been made practical through lightweight rotor construction, efficient ventilation, high torque characteristics, and shock resisting cast iron frames.

**New Disc Switch.**—The Square D Company, Detroit, has recently developed a new type of disc switch. The new switch has several advantages over standard designs, including front operation, and requires little mounting space. It has a quick make and break action and may be obtained either fused or unfused. Copper switch contacts reinforced by rustless steel springs, insure constant pressure and reduced heating. The switch is rated for either 30 or 60 ampere, single pole, two pole, two wire solid neutral or three wire solid neutral.

**A New Liquid Insulator.**—A new synthetic liquid insulator which has been announced by the General Electric Company not only has the advantages of mineral oil as an insulating and cooling medium for electric equipment but in addition is noninflammable and non-explosive. Designated by the trade name Pyranol, the material is produced in different forms for different purposes. For economic reasons, mineral oil will probably remain in general use for years, according to General Electric engineers at Pittsfield, Mass., but commercial installations of Pyranol indicate numerous applications where the new material is especially valuable. Capacitors can be made physically smaller per microfarad, with increased reliability; and the higher cost of transformers with Pyranol is justified when the equipment must be completely proof against fire and explosion hazards. Since the liquid is a solvent for some materials ordinarily used in electric equipment, particularly transformers, the apparatus must be designed specially for its use. Its dielectric constant (specific inductive capacity) is practically that of solid insulations, and its dielectric strength is of the same high order as that of mineral oil.

The liquid is chemically stable and it resists oxidation, so that there is no sludging after continued exposure to heat or air. It demulsifies, or separates from water, more than twice as rapidly as does mineral oil, and the moisture rises to the surface from which it may be evaporated. Viscosity and freezing point can be varied to suit conditions without affecting other qualities of the liquid. When Pyranol is subjected to an electric arc, the principal product is hydrogen chloride, an irritating but not actively poisonous gas which can be removed by an absorption device or piped to the open air for dissipation.

# Trade Literature

**Lightning Arresters.**—Bulletin 14325, 8 pp. Describes valve type lightning arresters. Line Material Co., So. Milwaukee, Wis.

**Arc Welder.**—Bulletin, 8 pp. Describes the new Lincoln "Shield-Arc" welder. The Lincoln Electric Co., Coit Rd. and Kirby Ave., Cleveland, O.

**Resistance Standards.**—Bulletin 100, 6 pp. Describes resistance standards and resistance measuring devices. Rubicon Co., 29 North 6th St., Philadelphia, Pa.

**Carbon Brushes.**—Catalog 13, 24 pp. Describes carbon brushes for single phase and other fractional horsepower motors. Boxill-Bruel Carbon Co., Columbia Park, O.

**Air-Break Switches.**—Bulletin 9324, 4 pp. Describes gang operated air-break switches for low cost construction. Line Material Co., Milwaukee, Wis.

**Electric Equipment for Mine Hoists.**—Bulletin GEA 1593, 24 pp. This bulletin is descriptive of General Electric practise and accomplishments in mine-hoist service in both coal and metal mining. General Electric Co., Schenectady, N. Y.

**Stainless Steel Tubing.**—Bulletin. Describes Carpenter stainless welded tube made from cold rolled stainless strip steel. Both the inside and outside surfaces of the tube represent surface metal from the original ingot. The Carpenter Steel Co., Welded Alloy Tube Div., 100 Broadway, New York.

**Smoke Density Meter.**—Bulletin. Describes the Brown smoke density meter which has been under development for a number of years, for recording and measuring the quantity or the color of smoke emission. The Brown Instrument Co., Wayne & Windrim Sts., Philadelphia, Pa.

**Water Softeners.**—Bulletin, 36 pp. The application of Zeolite water softeners to the treatment of boiler feed water is outlined; profusely illustrated with photographs and diagrams, and contains tabulated data, conversion tables, factors, reactions, etc. The Permutit Co., 440 Fourth Ave., New York.

**Rubber Paints.**—Bulletin, "Acidseal Paints." Describes a recently developed line of rubber paints. These paints have as a base a commercial form of rubber isomer, and retain the elastic properties of rubber, conforming to the expansion and contraction of the surface covered, and minimize the corrosive action of acids, alkalies, and chemical fumes. The B. F. Goodrich Co., Akron, O.

**Industrial Lighting Equipment.**—Catalog 219-A, 64 pp. This new catalog describes each unit plainly and lists them in a manner easy to find. A complete line of equipment is covered including new units, low priced industrial floodlights and quick change Wemco reflectors and sockets. Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

**Industrial Scales.**—Bulletin, 8 pp. Describes the improved line of Kron automatic industrial scales. Included are dial track scales, portable pan, portable platform, dormant platform, bench, hopper, crane, and pitless suspension types. All have been completely redesigned and the dial and lever mechanism considerably simplified. The Kron Co., Bridgeport, Conn.

**Circuit Breakers.**—Bulletin 1771-B, 8 pp. Describes manually and electrically operated oil circuit breakers, 7,500 and 15,000 volts, especially suitable for indoor power house use where space is restricted. De-ion grids have been used in some of the units. Bulletin 1958, 12 pp., describes another range of De-ion grid oil circuit breakers for indoor service in voltages from 15,000 to 34,500 and interrupting capacities from 500,000 to 2,500,000 kva. Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

**Propeller Turbines.**—Bulletin 38, 8 pp. Describes I. P. Morris propeller turbines having adjustable blades and fixed gates. These turbines are intended primarily for low heads and are designed to supply an efficient unit at a price lower than the price of the adjustable gate-adjustable blade propeller turbines with their two complete sets of control equipment. They are particularly indicated where the revamping of existing and less efficient plants is in contemplation. The bulletin includes power-efficiency curves, line drawings of the turbines and a "Chart of Characteristics for Standard Turbines" in two colors. Baldwin-Southwark Corp., I. P. Morris Div., Philadelphia, Pa.

**Meter Test Block.**—Bulletin CA-25, 8 pp. Describes a new type of plug-in meter test block, which permits easy connection and removal of the meter. The new block does away with meter loops and cross-overs in the meter connections. All cross-overs are provided in the base of the new block and the meter terminal connections slide down over semi-rigid connectors. Furthermore, unsightly wiring is eliminated, time is saved in installing or removing meters, and the meter links can be separately inserted or removed without disturbing the meter or base. The wiring order is the same as employed in ordinary test blocks and testing is accomplished with standard links, which are supplied. The block is built in indoor and outdoor meter cabinets. Switch and Panel Division, Square D Co., Detroit, Mich.

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MEMBERS of the Institute continue to make use of "Letters to the Editor" columns for the open-forum expression of their varied ideas on many subjects. *p. 813–15*

WHETHER OR NOT engineering progress benefits mankind depends upon how it is used, according to the fourteenth article in the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?" *p. 794–5*

IN THE FIRST 6 months of operation "not a single train delay has been caused by failure of the supervisory control equipment." Such is the report on the suburban electrification of an eastern railroad, all substations and switching stations of which are equipped with supervisory control. *p. 776–8*

BY DEPARTING from the conventional circular cross-section in cables used for transmitting electric power on overhead lines, the tendency of the cables to vibrate can be reduced; of several specimens tested, those having a triangular cross-section show least tendency to vibrate. *p. 795–8*

FROM an engineering study of the voltage and current wave forms of neon tubing commonly used for sign lighting, an explanation of its physical operation has been developed. *p. 772–5*

ENGINEERS have begun to plan for the relief of their unemployed during the coming winter. It is estimated that this year's needs will at least equal those of last year. *p. 809–13*

ALTHOUGH the thin oxid film with which aluminum protects itself from corrosion has been studied a great deal, only comparatively recently have thicker films produced "artificially" received much attention. These thicker films possess interesting properties and lend themselves to a variety of uses. *p. 778–80*

PEAKED voltage waves as narrow as 2 electrical degrees now can be obtained direct from a sinusoidal voltage source by the use of a specially designed transformer. *p. 802–4*

DEMAND for a simple and nondestructive method of testing finished welds has been met by an a-c bridge method with a visual balance indicator. Such a device is described in the A.I.E.E. 1931 national prize Branch paper. *p. 781–3*

PLANS for the A.I.E.E. 1933 winter convention already are assuming definite form. A general convention committee recently was appointed by President Charlesworth, and already has begun to arrange for the various events. *p. 807*

PREVIOUSLY published analyses of synchronous motor performance have been extended; from known formulas for the 3-phase short-circuit torque, expressions have been derived by which the torque from a single-phase short-circuit can be determined. *p. 799–801*

REGAINING stability in an electric power system is quite as important as maintaining it. To determine the proper operating procedure for quickly regaining synchronism once the system is out-of-step, an actual out-of-step condition on a large Pacific Coast system was exhaustively analyzed. *p. 769–72*

PROGRESS in insulation during the past year, both in theory and application, has been summarized in a report to the committee on electrical insulation of the National Research Council presented at the fifth annual meeting of the committee by its chairman, Dr. John B. Whitehead (F'12). *p. 765–8*

REGISTRATION at the recent A.I.E.E. district meeting at Baltimore totaled 240, attesting to the general interest value of the technical sessions as did the quality and quantity of discussions presented. Meetings of the Institute's board of directors, District 2 executive committee, and power generation committee, were held. *p. 805–8*

EVEN IN TIMES of low copper cost carrier communication has proved to be an economical means of conveying both telephonic and telegraphic information. A 10-channel 4-wire carrier telegraph system is capable of handling 3,360 words per min. *p. 784–9.* To lessen the labor involved in designing the shaping networks of this system, a direct method of solving coupled tuned circuits was developed. *p. 789–94*

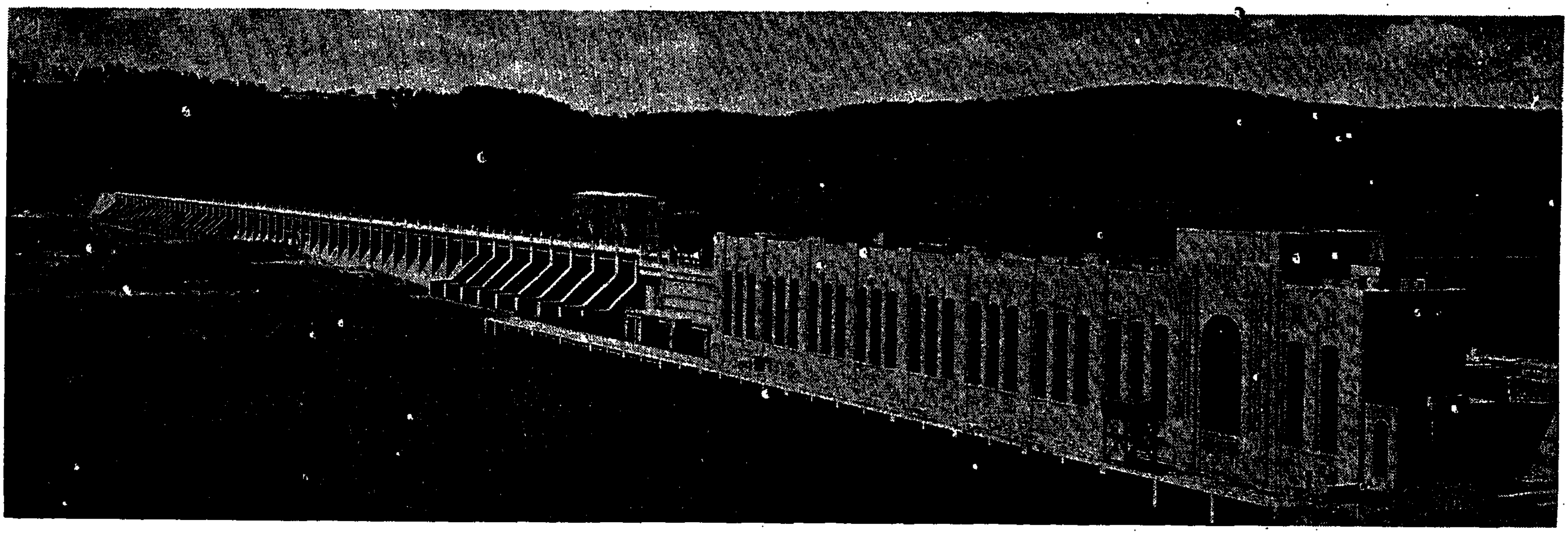

Fig. 1. General view of Safe Harbor plant and dam

# The Safe Harbor Hydroelectric Development

**At Safe Harbor, Pa., has been built the third major hydroelectric plant on the lower reaches of the Susquehanna river. With an ultimate installed capacity of 510,000 hp in turbines, it is destined to become one of the largest hydroelectric developments in the United States. Turbines are of the propeller type with automatically adjustable blades; they are said to be the most powerful of this type ever built. Many interesting details of the development are revealed in this article.**

By
N. B. HIGGINS
MEMBER A.I.E.E.

Safe Harbor Water Pwr. Corp., Baltimore, Md.

WHEN COMPLETED, the Safe Harbor plant will be one of the largest hydroelectric plants in the United States; initial development will include 6 generating units, which in an average year with full utilization will have an output of over 800,000,000 kwhr. The plant is situated along the Susquehanna river a few miles south of Columbia, Pa., and about 1,100 ft upstream from the mouth of Conestoga creek. The development ultimately will have an installed capacity of 510,000 hp in 12 Kaplan turbines, each of 42,500-hp capacity, operating at a speed of 109.1 rpm under a head of 55 ft. Ten of these turbines will drive 36,000-kva 60-cycle 3-phase, 80 to 100 per cent power factor, 13,800-volt generators; and 2 will drive 37,500-kva 25-cycle single-phase, 80 per cent power factor, 13,300-volt generators. Included also in the ultimate plan are 4 25/60-cycle frequency changers of the outdoor type, the generating ends of which will be rated at 31,250 kva, 80 per cent power factor, 300 rpm, 13,300 volts.

Initial development includes 5 60-cycle units, one 25-cycle unit, and one frequency changer; 4 60-cycle units are now in operation, and it is expected that another 60-cycle unit, one 25-cycle unit, and a frequency changer will be installed before the end of 1933.

A major problem in electrical design at Safe Harbor has been to produce a flexible layout, which will permit the installation as required of equipment for generating, transforming, and transmitting 60-cycle 3-phase, and 25-cycle single-phase energy. All generating equipment and the 60-cycle low-voltage bus are located in the power house; all 60-cycle transformers are of the outdoor type, and are located adjacent to the power house. A combined 69-kv and 230-kv 60-cycle substation ultimately will be built on the top of the hill, directly east of the power house. The frequency changers, 25-cycle low voltage bus, and 132-kv 25-cycle step-up substation will be located east of the power house.

One 230-kv circuit has been constructed between Safe Harbor and the Westport station of the Con-

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Based upon "Safe Harbor Project" (No. 32-123) presented at the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., Oct. 10–13, 1932.

solidated Gas Electric Light and Power Company in Baltimore, Md., and another will be constructed within the next few years, over a separate right-of-way entering the city from the east. A 69-kv double-circuit transmission line, about one mile in length, has been constructed to tie Safe Harbor into the existing 69-kv system of the Pennsylvania Water and Power Company.

The power house is in line with, and forms a continuation of the dam. The substructure is of reinforced concrete, and the superstructure of brick and tile. The total combined length of the concrete dam and power house is 5,000 ft, made up as follows: power house, 916 ft; bulkhead and abutments, 2,274 ft; spillway, 1,810 ft. The entire spillway is equipped with crest gates. General arrangement of structures is shown in Fig. 2.

In extent of drainage basin, and in total and average runoff, the Susquehanna river is the largest river flowing into the North Atlantic ocean, with the exception of the St. Lawrence. Its watershed includes 27,400 sq miles in the states of New York, Pennsylvania, and Maryland. Yet, in spite of this vast tributary area, the stream itself is of little use in commerce; there is practically no navigation above the tide-water limit, which extends only 5 or 6 miles upstream from the mouth of the river.

From Columbia to Tidewater, a distance of 39 miles, the river is walled in by steep bluffs or hills, and the main channel varies in width from a few hundred yards to almost 2 miles. Because of these conditions there has been no industrial development, other than transportation, in this reach of the river. These conditions of rapid descent, steep banks, and the absence of populous towns in a region close to large industrial centers, made this part of the river attractive from a power development standpoint.

Backwater from the dam extends 10 miles upstream forming a lake varying in width from 0.4 mile to almost 2 miles, covering an area of 10.5 sq miles. The water stored in the top foot of the pond is approximately 310 million cu ft; total useful storage is about 3 billion cu ft.

On the east side of the river, 8.5 miles of the Columbia & Port Deposit branch of the Pennsylvania Railroad had to be raised, and on the west side some highway relocation was required; otherwise, improvements effected within the reservoir limits were negligible.

HYDRAULIC STRUCTURES

It was desired to obtain full control of the forebay level for all possible river flows and to maintain constantly the maximum permissible forebay elevation, except when lowering would be desirable to make use of storage. This required a spillway that could be controlled with crest gates for its full length, and capable of discharging the greatest flood assumed possible at the given forebay elevation of 225 ft. Several comparative estimates were made to determine the most economical combination of size and number of gates to produce these discharges. The final analysis resulted in selecting 32 gates for openings 35 ft high and 48 ft wide; tops of gates are 5 ft above initial normal pond level to prevent excessive loss of water from wind action.

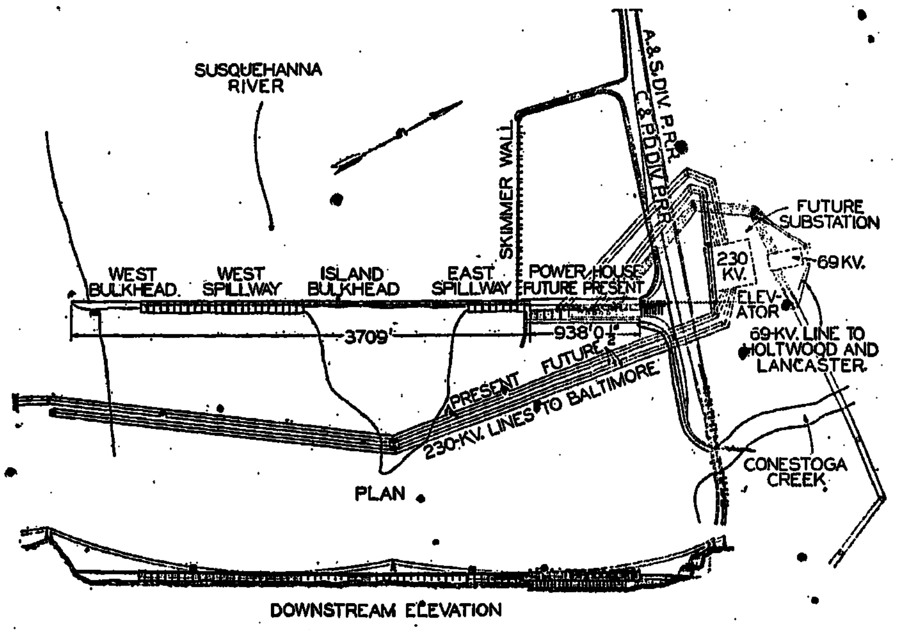


Fig. 2. General layout of structures

At normal forebay level each flood gate will discharge about 30,000 cfs; the west spillway, where 24 of the 32 gates are situated, thus has a discharge capacity of 720,000 cfs, which is equal to the maximum flood of record.

Bulkhead sections are conventional gravity structures; they are designed for compression over the entire foundation joint for headwater at el 228, 10,000 lb per lineal foot of ice pressure at the same elevation, and uplift corresponding to full head at the heel decreasing to tailwater head at the toe following a gradient determined by the foundation drainage system. Design of the spillway is based upon the same assumptions, except that ice pressure there was reduced to 4,000 lb per lineal foot, acting on the gates and transmitted to piers. The lower assumption was considered justified because a compressed air bubbler system has been incorporated in the design to prevent ice pressure from acting on the gates.

The spillway has an overhung crest and a large bucket type of apron; otherwise, it is of the usual ogee cross-section. Shapes of the apron, spillway nappe, and pier noses, were determined by model tests in the Alden laboratory of the Worcester Polytechnic Institute. The dam stands on a sound rock foundation of quartz, mica schist, and phyllite. Because of the excellent quality of the foundation, the strike of the folds, and the dips of the stratum, no cutoff trench was required; natural conditions made it possible, in effect, to obtain cutoff trench advantages at little additional cost. Rock was removed by blasting operations, the average depth of excavation being 11 ft.

Crest gate equipment consists of 28 single-leaf Stoney flood gates, and 4 double-leaf regulating gates, the lower leaf of which is a Stoney gate and the upper leaf a fixed roller gate; there are also 2 emergency gates with fixed rollers. The upper leaves of the 4 regulating gates are operated normally by lowering them and discharging water over the top. By means of these gates, close regulation of pond level can be maintained, and floating debris and ice can be removed easily with a minimum waste of water.

Débris and ice usually will accumulate along the skimmer wall, for which reason the 4 regulating gates are located adjacent to the power house. Upper leaves of the regulating gates are operated by individual hoists located in a tunnel in the body of the dam directly under each gate. Hoist motors for the regulating gates have operating controls at the hoists and also in the power house switch room.

All crest gate equipment is handled by 2 gantry cranes of 150-ton capacity each. These cranes are served from a trolley bus on the operating bridge; in addition, one of the cranes is equipped also with a gasoline engine-generator set for emergency operation.

It is believed that every reasonable precaution has been taken to insure the safe operation of the crest gate equipment under the most unfavorable combination of circumstances. The following features are noted:

1. Large excess capacity of the gantry cranes.
2. One crane can handle gates with sufficient rapidity to meet any normal condition; 2 cranes are provided.
3. Different sources of power for the gantries.
4. Equipment to heat electrically the roller tracks and seal plates on the gate guides.
5. A compressed air bubbling system to prevent ice formation on the upstream side of the gates.

Flood gates are of the usual design of horizontal fabricated girders supporting a skin plate through vertical intermediate beams. The respective weights are 86 tons each for the flood gates (excluding roller trains), and 100 tons each (including fixed wheels) for the emergency gates.

## Power House

Site selected for the power house is in the low-water channel of the river near the Lancaster county shore; minimum excavation for power house and tailrace was an important consideration in the selection of this site. The ultimate length of the power house will be 916 ft; the initial section is 642 ft long, with space for 7 main generating units. A railroad connection extends directly into the generator room assembly bay.

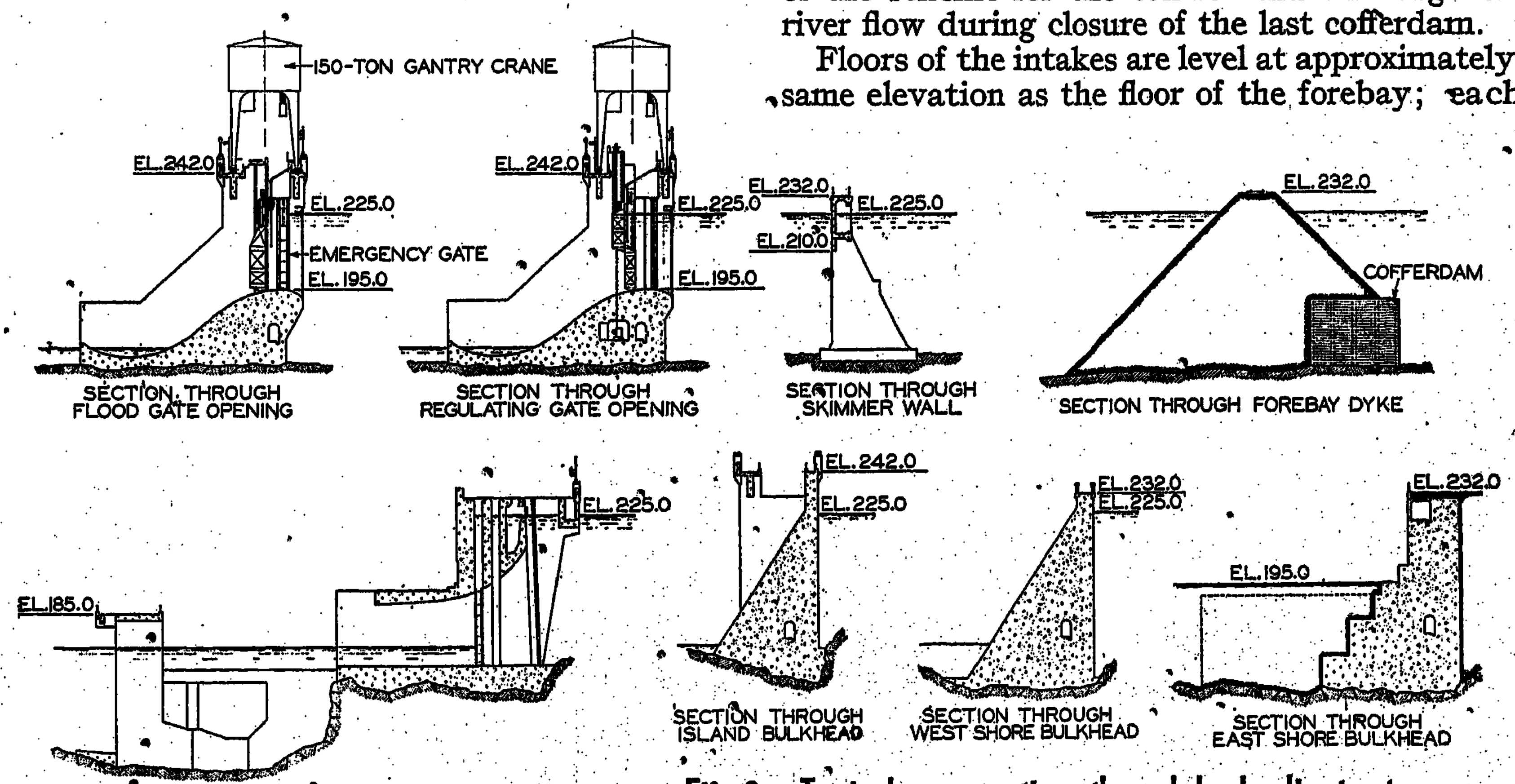
Physical dimensions of the Safe Harbor turbines are the largest for this type of unit so far installed in this country. The maximum scroll case and draft tube width is 55 ft; thickness of piers between units is 7 ft, making the unit spacing 62 ft. Below the water line all contraction joints are sealed with crimped sealing strips made of 24-oz copper, while construction joints between lifts of concrete are sealed with flat copper strips.

Offsetting by 2.5 ft the transverse center line of units with the transverse center line of the intakes presented some difficulty in lining up the piers between waterways; this was overcome by slightly tilting the upper part of the draft tube. Characteristics of the turbines selected required a deep draft tube, but the influence of this on volume of tailrace excavation was reduced by sloping the bottom of the outflow end of the tube upward at the steepest permissible angle without affecting the draft tube efficiency. From low point to exit the draft tube is divided into two equal outlets by a 5-ft pier. For unwatering, the tube can be sealed by a set of sliding gates which are handled by a 25-ton gantry crane from a bridge over the tubes.

From the draft tube outlets the tailrace floor slopes upward to intersect the natural river bed at an angle of 6°. The maximum depth of rock excavation was about 40 ft, 180,000 cu yd of solid rock being excavated to form the tailrace channel. This excavation is the total for the ultimate plant; likewise, the substructure was excavated for all future units.

Intake portion of the power house substructure for the 5 future units was completed, excepting that no intake gate hoists or screens were installed. Intake gates for future units were an important part of the scheme for the control and discharge of the river flow during closure of the last cofferdam.

Floors of the intakes are level at approximately the same elevation as the floor of the forebay; each in-



SECTION THROUGH FLOOD GATE OPENING

SECTION THROUGH REGULATING GATE OPENING

SECTION THROUGH SKIMMER WALL

SECTION THROUGH FOREBAY DYKE

SECTION THROUGH UNFINISHED POWER HOUSE

SECTION THROUGH ISLAND BULKHEAD

SECTION THROUGH WEST SHORE BULKHEAD

SECTION THROUGH EAST SHORE BULKHEAD

Fig. 3. Typical cross-sections through hydraulic structures

take consists of 3 water passages, with smooth sloping bell mouths. The cross-section of the water passages at the head-gates measures 15 ft 8 in. wide by 29 ft $4^1/_2$ in. high. Each water passage is controlled by one intake gate; slots are provided in the head works in front of head-gates for the placing of emergency gates when head-gates are taken out of service. Velocities through the gross area of the intake cross-sections vary from 3.32 ft per sec at entry to 7.25 ft per sec at the scroll case intake.

The center gate of each intake travels on fixed rollers, and is operated by a motor-driven screw hoist; the 2 outside gates are sliding gates, and are handled by a 50-ton intake gantry crane, of which 2 are provided. The screw-hoist-operated gate can be raised or lowered under full unbalanced water pressure. The sliding gates are designed to be handled under balanced water pressure only. Emergency valves are provided in the sliding gates for filling the intakes in the event of screw hoist motor failure. The omission of hoisting mechanism on $^2/_3$ of all head-gates resulted in a substantial saving in cost, and does not slow up the starting operation appreciably as a unit can be started with the center gate alone open. Emergency gates are similar to the sliding head-gates and are handled in the same manner.

Intake screens are of welded construction throughout. A single intake screen is made up of 5 vertical sections 12 ft high by 18 ft wide, and slides in slots similar to the gate slots. The face of the screen has a batter of 1 in 24. Individual screen bars and their supporting frame are designed for an unbalanced head of 15 ft of water. Screen bars and supports of streamline shapes were designed to offer a minimum resistance in the water passages. In addition to reducing the loss of head, a flow free of eddies will decrease the tendency for frazil ice to adhere to the screens.

There is provision for a mechanical trash rake, but the rake will be installed only if found necessary. Surface trash and ice that may collect at the turbine intakes can be discharged directly over the screens into the trash sluice built into the substructure. The crest elevation of the sluice is one foot below normal forebay level, and is closed off from the forebay by gates; these gates when raised permit the discharge of all floating debris into the sluice, from where it is carried directly to the tailrace. Compressed air can be discharged at points on the periphery of the intakes to dislodge and float waterlogged debris.

In addition to providing for heating the screens electrically, should this prove necessary, another means to reduce or eliminate ice troubles in the intakes is a provision to discharge the air from the exhaust duct tunnel of the power house ventilating systems, into the space over the screens and below the intake deck.

## Arrangement of Electrical Structures

The electrical bay of the power house, as may be seen from Fig. 4, is between the generator room and the intake structures. It consists of 3 floors housing switching equipment. The lowest floor is occupied by the 2 buses and their taps; the second floor houses oil circuit breakers and disconnecting switches; the third contains potential transformers and reactors. A vertical reinforced concrete fire wall separates the 2 buses and their associated switching equipment. Crosses are made only at those points where taps are taken off to machines, and special attention has been paid to making these vapor-tight.

Above the electrical bay are the transformer pockets, each approximately 40 x 30 ft in size and separated by vertical fire walls one foot thick. Below each transformer is a basin, drained to the tailrace and of sufficient size to accommodate all of the oil in the transformer tank.

The takeoff structure supporting the isolating transformer disconnectors, the lightning arrester disconnectors, and outgoing lines across the forebay are directly above the transformers. Safe and quick maintenance on all switching equipment on this structure is made possible by a complete system of access ladders and working platforms.

In the center of the station a space 165 ft long above the electrical bay is devoted to the control and terminal rooms, batteries, station service transformers, and station service switchboards.

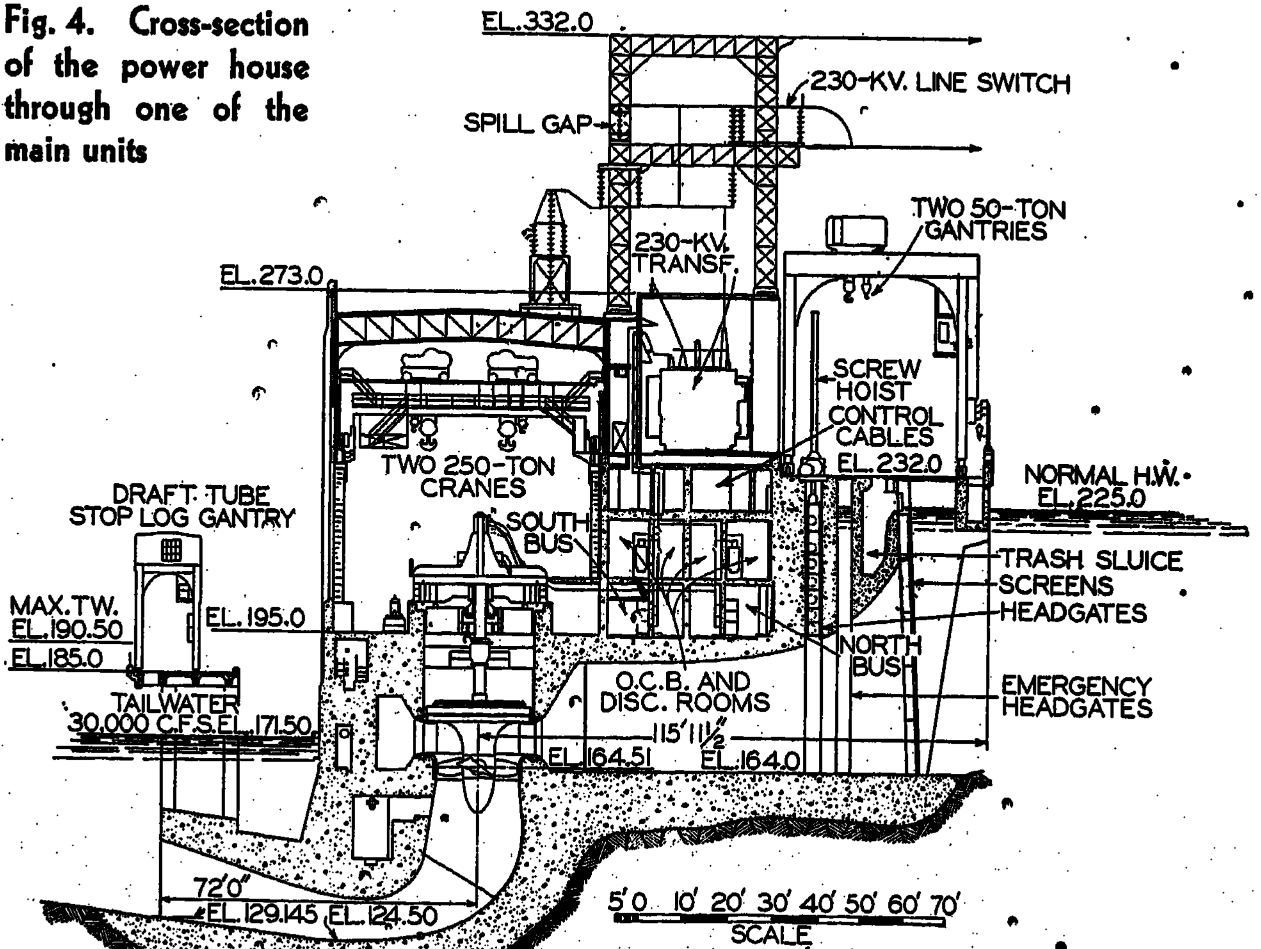


Fig. 4. Cross-section of the power house through one of the main units

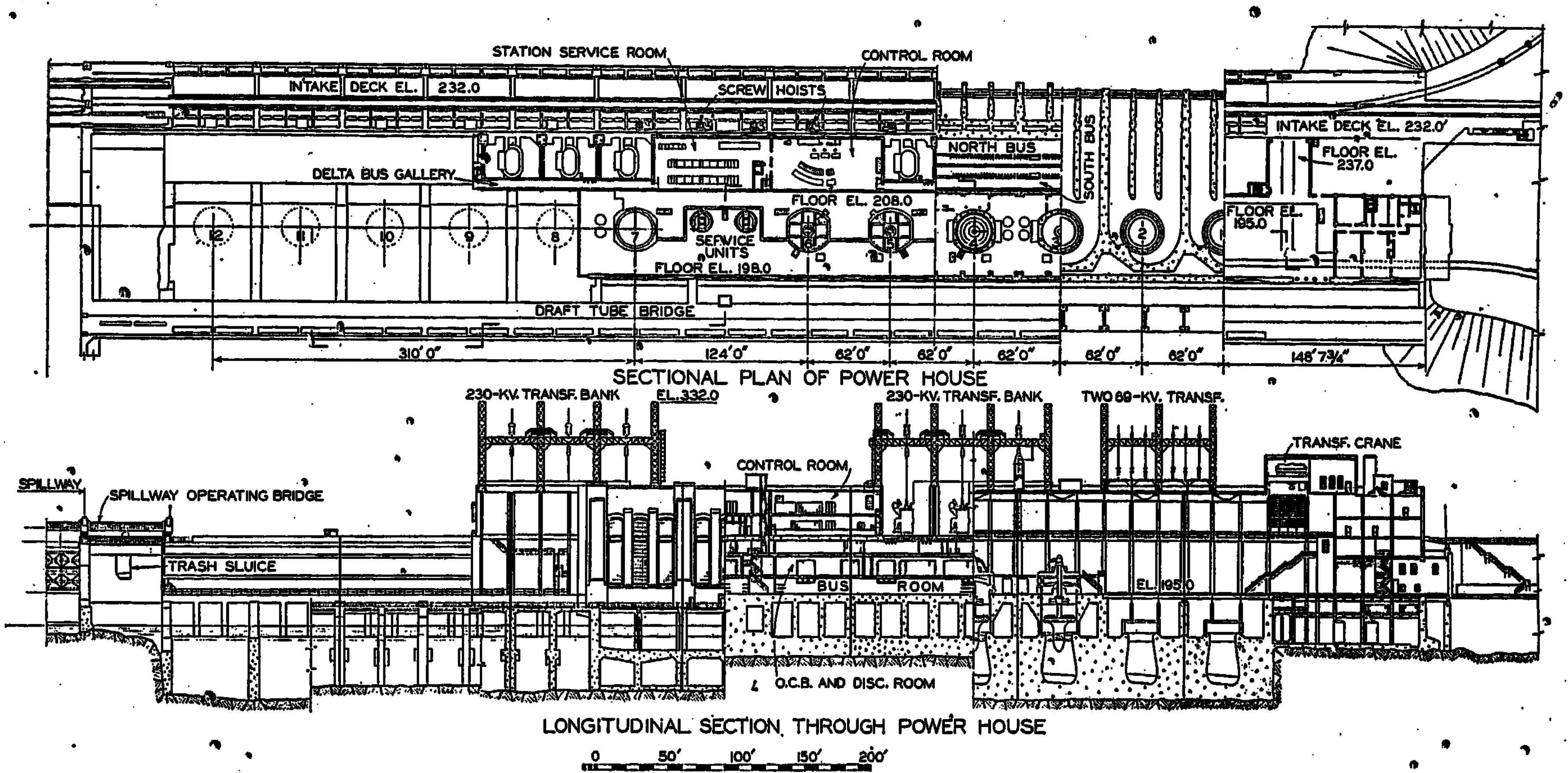


**Fig. 5. Sectional plans and elevations of the power house**

### 60-Cycle Generating System

The 60-cycle generators, of which 4 now are installed, are 3-phase machines, each rated at 36,000 kva, 80 to 100 per cent power factor, 13,800 volts, at 80 deg C temperature rise in both armature and field. As may be seen from Fig. 6, these generators feed into a double bus system which ultimately will consist of 8 sections with 4 sections per bus. The bus and its connected equipment are designed to operate ungrounded; therefore the generator neutrals have been grounded only through potential transformers to which ground indicators are connected. From this bus power is supplied to the 230-kv and 69-kv step-up transformer banks of which ultimately 3 each will be installed. Equipment is connected to the bus by selector oil circuit breakers. Reactors will be installed as needed to hold the short circuit values below 1,500,000 kva.

Only the simplest high voltage switching is provided at the power house. This consists of a motor-driven isolating disconnect with ground switches for each transformer. Lightning arresters, spill gaps, and the lightning arrester disconnecting switches for protecting the transformers also are located at the power house, one set being connected to the outgoing leads of each transformer. At the present time there is no high-tension bus, each transformer bank being connected directly to a transmission line. Either or both of the 2 230-kv transformer banks can be tied to the single 230-kv Baltimore circuit.

The generators are of the overhung rotor type (see Fig. 7) with water-cooled guide and thrust bearings combined in a single housing below the rotor. Guide and the thrust bearings are of the adjustable segmental shoe type; the thrust bearing is designed to carry a total weight of 1,500,000 lb, including a water thrust of 1,100,000 lb. These machines are designed to withstand overspeed to 231 per cent of normal, which value, like that of the water thrust, is somewhat greater than usual on account of the characteristics of the Kaplan turbines.

Diameter of the generators is 29 ft 2 in. and the height 29 ft measured from the lower face of the coupling to the top of the Kaplan head. The weight of a complete machine is approximately 400 tons.

Manufacturers of the generators cooperated in the design of the machines in order to make parts interchangeable as far as possible; those parts exposed in the generator room are identical in appearance.

Class B material is used throughout for insulating the generators. While it is not believed that machines of this size and importance should be operated continuously at the 80 deg C temperature rise, it was decided that excitation should be provided to permit development of the rating corresponding to this rise for use during peaks or emergencies. Normal operation at approximately 28,000 kw, 90 per cent power factor falls within the 60 deg C temperature rise in both armature and field, a rise generally accepted as conservative design practise for this class of insulating material.

A closed system of recirculating air is employed for cooling the generators. Air is introduced below the rotor and is forced by fans attached to the rotor through the windings into an eccentric frame, which serves as a duct to collect and conduct the hot air to the surface air coolers located on diametrically opposite sides of the machines (see Fig. 7). A gravity system of water supplied from the forebay serves the coolers. The air path is totally enclosed throughout; the ducts are equipped with louvres which may be opened as required to bleed air for heating the generator room. The closed system of ventilation was selected rather than open ventilation for the following reasons: reduction in space; better control of generator temperatures; better fire fighting possibilities, and the exclusion of foreign material (particularly construction dirt).

## OIL CIRCUIT BREAKERS AND DISCONNECTS

Oil circuit breakers are insulated for 25 kv and are designed to interrupt successfully 1,500,000 kva at 13.8 kv. They are cell mounted with each tank in an individual concrete cell. Generator and 69-kv transformer breakers are rated at 2,000 amperes, and have normal speed of operation. The 230-kv transformer breakers are rated at 3,000 amperes (2 are used in parallel) and have a guaranteed opening time of 8 cycles from application of tripping current to clearing of arc. Bus tie and bus section breakers are rated 4,000 amperes, and are designed to open at normal speed.

All circuit breakers are interlocked mechanically with their isolating disconnectors. Interlocking is effected further throughout high voltage electrical areas, where the Cory system is used to lock switches and bus doors on 13.8 kv, and switches on 69 and 230 kv. Special precautions were taken to isolate the oil circuit breakers; they are in separate rooms with, in general, not more than 4 breakers in a room. Carbon dioxide fire protection is provided for these rooms, and oil sumps below each breaker tank are drained to the tailrace.

Disconnecting switches isolating the oil circuit breakers are designed so that the 6 poles are operated by one mechanism. When in the open position they are swung into ground clamps, thus isolating and grounding the breaker. All disconnecting switches are mounted on insulators interchangeable with those supporting the bus runs and taps.

## 230-KV TRANSFORMERS

The 230-kv transformers are of the combined gas filled-conservator type in which a 16-in. nitrogen filled space, directly below the cover, is kept under positive pressure by the head of oil in a standard conservator. Expansion and contraction is taken care of by variation of the conservator oil level. They may be operated as standard conservator transformers, if desired.

At present 2 230-kv transformer banks have been installed. Each bank has a normal capacity of 84,000 kva when operating self-cooled, and 126,000 kva with blowers in operation. One bank only is now complete with blowers; blowers are omitted on the second bank because at present it is used only as an emergency spare bank.

The 3 single-phase units comprising each bank are in individual cells; they are Y-connected on the 230-kv side and Δ-connected on the 13.8-kv side. The high voltage neutral is solidly grounded, but the installation is such that the banks may be grounded later through an impedor of such size as will hold the transformer neutral voltage below 76 kv. Four 2½-per cent taps are provided in the high tension winding, 2 above, and 2 below 230 kv. The transformers are insulated to withstand an induced test of 461 kv. Their windings and bushings are designed to be coordinated with each other and with a 46-in. protective gap on the high-tension structure adjacent to the transformers. Each transformer is protected by a thyrite lightning arrester mounted on the power house roof adjacent to the transformers.

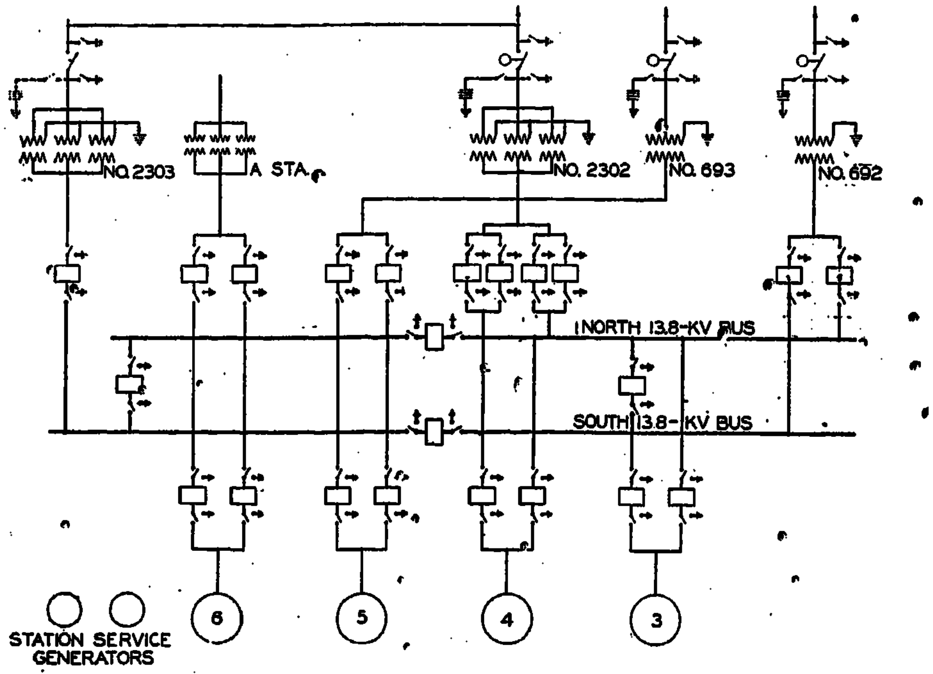


**Fig. 6. Single-line diagram of the 60-cycle system**

Note that each main transformer is connected directly to a transmission line

In addition to the 230-kv transformers, 2 69-kv transformer banks have been installed; these are 3-phase 30,000-kva self-cooled banks of the inertaire type, equipped with blowers to increase this rating to 45,000 kva. They are equipped for tap changing under load over a range of 10 per cent above and below 66 kv. Each transformer is protected by an autovalve lightning arrester mounted on the roof close to the transformer leads; protective gaps are not used at this voltage.

## AUXILIARY POWER SUPPLY

Major auxiliaries at Safe Harbor are supplied at 460 volts from 2 2,500-kva, 70 per cent power factor, house generators, and a single-phase transformer bank of 2,500 kva capacity connected to the main 13.8-kv bus. The house generators are of the umbrella type, and are driven at 180 rpm by 3,100-hp Francis turbines.

There are 2 station buses, each of 2 sections, complete with section switches and one bus tie switch. Positions are available for connecting each of the house generators and the transformer banks to either bus; normally one house unit is connected to each bus. These buses are isolated from each other, each being contained in a steel structure and the 2 separated by a 7-ft aisle. Generators, transformer, and tie and section circuit breakers are of 4,000-amp capacity. All feeder breakers are of the truck type.

## EXCITATION SYSTEM

The unit system of excitation has been adopted, supplemented by a motor-driven spare exciter supplied from the station auxiliary system. Each of the main generators receives excitation from a 185-kw 250-volt main exciter and pilot exciter, both mounted above and direct-connected to its generator, Provision is made for the future addition of a second spare exciter, if found necessary.

Generator main field rheostats are not required, as the generator voltage is controlled by varying the fields of the main exciters. The excitation system is designed for a moderately high rate of response of the order of 100 volts per second. Parallel fields on the main exciter are used to produce that response. An auxiliary field, in which the excitation may be reversed as desired, is provided in each exciter to take care of sudden major changes in voltage. The excitation of each unit is controlled by a high-speed voltage regulator.

## CONTROL

In this station 250-volt control is employed. Duplicate batteries, each with an 8-hr discharge rate of 95 amp to 1.75 volts per cell, are provided. These are equipped with a tap to permit their use for 250/-125-volt auxiliary lighting. Normally, one battery is used for control, the other for emergency lighting and other miscellaneous d-c requirements.

Switching and control for batteries and chargers, and switches for d-c distribution are housed in a dead front steel switchboard. D-c distribution at the main switchboard is handled from duplicate control buses through dead front disconnecting fuses housed in distribution cabinets.

## MAIN GROUND SYSTEM

The island in the middle of the river offered an excellent location for ground electrodes, but it was a considerable distance from the power house. However, 4 ground mats, each consisting of approximately 20 rods connected to 2 500,000-cir-mil cables by a network of 4/0 cable, were located on this island; single lengths of 500,000-cir-mil cable, 300 ft long, were placed along the face of the dam. Inasmuch as this entire area is submerged, great care was taken to braze all joints thoroughly, and to break the network into several parts, the terminals of which were brought in through the face of the dam and connected together inside by 2 500,000-cir-mil cables running through the inspection tunnel. The loss of one or more of these incoming feeders from the network should not reduce seriously the protective value of the ground.

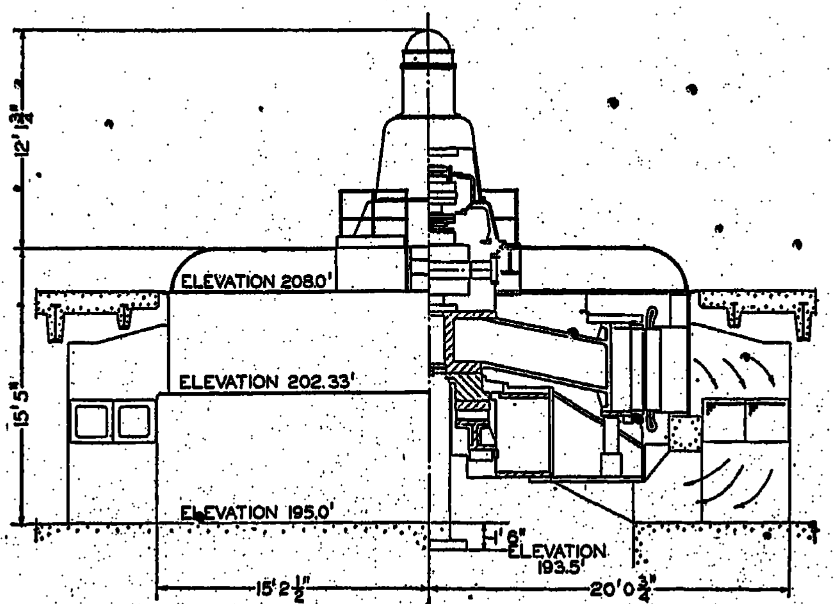


Fig. 7. Cross-section through a main 60-cycle generator

To obtain a direct path for lightning arrester grounds, several 1,000,000-cir-mil cables were carried from the lightning arrester location on the roof, out into the forebay, and terminated in connections to heavy rail sections. These cables were connected to gate guides and other submerged metal passed on the way to the forebay. It is expected that the amount of contact surface offered will give a fairly low resistance.

At the shore end of the power house directly adjacent to the rock fill on the railroad is a section of quiet water. It is expected that considerable silting will take place at this point; therefore, a network of cables, with a backbone of 500,000-cir-mil feeders, is laid there.

Two 500,000-cir-mil cables join the ground mats on the island with those in the forebay and those in the shore end of the forebay. In addition, heavy 5 x $^1/_4$-in. copper buses in parallel with these cables connect all grounds in the power house area. From these heavy buses are run auxiliary grounds to all sections of the station. Transformer banks are connected directly by short loops to the cables from the lightning arresters to the forebay. Transmission line ground wires are tied to the power house grounding system at several points in the vicinity of the power house.

## COMMUNICATION

A Bell telephone system with a central exchange located in the control room is used for telephone communication throughout the power house. This is supplemented by an autocall system with stations throughout the power house, dam, and substations, and by an operating-order signal system between switchboard and turbine gage boards on the operating floor. To advise the operating staff of unusual operating conditions, a system of telephone annunciator drops is used.

## RELAYS

Both the main and house generators are equipped with differential relays which shut down the unit completely. They are equipped also with overspeed and over-voltage relays with contacts in series. These act to open the main and field breakers and to bring the unit to rated speed with no load.

Provision is made for differential protection on the main buses; however, this protection is not yet installed.

Main transformer banks are equipped with differential relays, which protect a zone between the high-voltage bushing current transformers and the low-voltage bus. The 230-kv transformers are equipped in addition with a high voltage winding differential scheme.

As each of the main transformer banks is connected directly to a line, line and transformer protection is somewhat correlated. High speed impedance relays are used as protection against phase-to-phase faults. These are backed up by straight overload relays. Inasmuch as there are at present no high voltage buses on the system, ground protection is secured by the use of relays connected in the neutrals of the power transformers.

### MAIN TURBINES

An outstanding feature of the plant is the Kaplan turbines, the blades of which are adjusted automatically as the load changes, to maintain high efficiency over a wide range of load; also, the relation between blade angle and gate opening can be varied manually to compensate for changes in head.

[Editor's Note: For details of the design and setting of these turbines see "Kaplan Turbines for Safe Harbor Hydroelectric Plant," by Davis and Spaulding, ELECTRICAL ENGINEERING, October 1932, p. 728–33.]

Selection of this type of turbine followed an extensive investigation covering turbine units equipped with the 4 principal types of runners, namely, the Francis type, the propeller high speed type with fixed blades, the propeller high speed type with manually adjustable blades, and the Kaplan high speed type.

To eliminate the objection of poor economy under varying loads, an investigation was made of the use of one Kaplan unit with governor adjusted runner blades, in combination with 5 propeller fixed blade runner units. The horsepower-efficiency characteristic of the Kaplan runner is quite flat and, consequently, high efficiencies are maintained as the load on the unit is reduced. With such a combination of units, and with the propeller fixed-blade runner units all operating at best efficiency and the Kaplan unit taking the load swings, reasonably good economy in the use of water may be secured.

Kaplan runners with their adjustable feature may be operated with the blades wider open than the fixed blade position on the propeller runner. Consequently, for a given wheel diameter, the Kaplan runner will have a higher maximum power, or, with the same power, a smaller runner diameter with a corresponding reduction in the spacing between units may be secured. The higher capacities are, of course, contingent upon the runners being set sufficiently low for these capacities to fall within the power limits set by cavitation.

For small turbines the difference in first cost between Kaplan turbines and turbines with fixed blade runners is appreciable; as the turbine size increases, however, the percentage difference becomes less, and for units of the size selected for Safe Harbor, becomes small and is practically negligible compared with the total cost of the development. As the units in this station are required to furnish energy over 2 separate systems, it was decided that at least 2 Kaplan units should be installed for each system group, so that one will be available at all times for economical regulation of the load should the other unit be out of service. In addition to the foregoing, certain other advantages accrued from the use of *all* Kaplan turbines with automatically adjustable blades as finally selected for this plant. These are the highest powered Kaplan turbines in the world; the runners are 220 in. in diameter, and will discharge about 9,000 cfs at full gate and normal head.

Two means of unwatering the wheel casing have been provided. In one scheme the tailwater can be lowered automatically by admitting compressed air to the wheel casings. As the gates on these units approach the no-load position, an air valve will open and admit compressed air to the wheel casing. If the gates are closed, as when running reserve, or as a synchronous condenser, air pressure will be maintained automatically in the wheel casing and will depress the water level below the runner. The alternative method of unwatering the turbines for inspection or maintenance is to put stoplogs in the discharge end of the draft tube and pump out the water with portable 10,000-gpm unwatering pumps.

Speed rings are of cast iron in 4 sections, containing a total of 20 stationary vanes cast integrally with the upper and lower rings; the over-all diameter is approximately 28 ft 10 in. The speed ring and stationary speed ring vanes are cored hollow, and provision has been made for introducing steam inside the vanes as a protection against the accumulation of frazil ice. Provision also has been made for the discharge of steam into the scroll cases, after these passages have been unwatered, to aid in dislodging any frazil ice which may have formed, and to sterilize the wheel pits.

Turbine guide bearings are of the babbitt lined, oil lubricated type. One belt driven pump is used to circulate the oil in normal operation. A motor-driven pump also is installed to start automatically through the action of a flowmeter should the flow of lubricating oil in the supply line be reduced to the minimum quantity required for proper lubrication.

Turbine operating mechanism consists of 20 movable cast steel gates actuated through 2 oil pressure cylinders connected to the gates through an operating ring and suitable links and levers. This mechanism is protected from injury by the use of shearing pins inserted through the upper and lower sections of the gate lever, one section of which is keyed to the gate stem.

### GOVERNORS AND PUMPING SYSTEMS

Governor equipment is required to perform the double function of regulating the speed and controlling the pitch of the runner blades. Consideration was given to the following features: degree of protection against outage of the units due to failure of any part of the governor system; sensitive regulation of speed; convenience in operation; space required. After carefully considering 3 types of governing systems, the twin system was adopted; this system includes for each pair of units: 2 governors, 2 motor-driven pumps, 2 pairs of pressure tanks, and one common sump tank with 2 compartments.

Governors are of the oil pressure actuator type with motor-driven flyballs; they are of light construction, a desirable characteristic for sensitive operation and quick response to changes in speed.

Pumps are of the herringbone gear type, motor driven. This equipment is interconnected so that one pump may be used for the operation of either one or both of the main units and the second pump held in reserve as a spare unit. Each pump is equipped with a pressure starting switch to provide for the automatic starting of the pump held in reserve should the pressure in the supply tanks fall below the minimum pressure limit setting for the first pump. Unloader valves are installed to permit continuous operation of these pumps, if desired, in which case the oil will be by-passed automatically to the sump tanks when no additional fluid is required in the pressure tanks. Should it be found desirable to take either pair of pressure tanks out of service at any time, the pipe connections are such that both main units may remain in service, with one on governor and the other on hand control.

With this arrangement of equipment, a high degree of protection against outage is obtained, as the 2 main units served by each system may continue to operate with any one piece of governor system equipment temporarily out of service.

Each governor is equipped with a safety shutdown torque motor and solenoid switch, to provide for automatic closure of the turbine gates, to either the speed no-load or completely closed position through the operation of any one of several protective relays. Characteristics of the torque motor are such that it will not permit the opening of the turbine gates beyond speed no-load position until the voltage has reached from 50 to 60 per cent of normal (at which voltage the flyballs will assume control) except by hand through the release of a mechanical lifter. It is designed, also, to prevent the gates from opening when starting up should one phase of the three-phase governor flyball motor circuit be open. After the motor has been placed in service, the gates will be closed automatically when voltage drops to approximately 40 per cent of normal, but will remain open with one of the 3 phases of the governor supply open, should the voltage remain approximately normal. Governor flyball motors are driven from the pilot exciters on the main unit shafts through slip rings, and operate at 163 volts, 7.27 cycles.

Movement of the turbine blades is accomplished through a piston in the shaft cylinder, which is connected with the operating mechanism in the runner hub through a vertical rod within the turbine shaft. The piston is operated under oil pressure admitted to and discharged from the cylinder through 2 concentric pipes within the generator section of shaft. For every position of the turbine gates, the runner blades are moved to a corresponding position to develop the best turbine efficiencies through a wide range of load. The flow of oil to and from the shaft cylinder is controlled by a valve connected through a cam to the turbine gate operating mechanism. The relation of the turbine gate openings to the position of the runner blades is allowed to remain fixed within approximately a 4-ft variation in head. Beyond this range other cams, which may be quickly and conveniently shifted into position, are employed to insure reasonably high efficiencies under a wide variation of head.

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# A Résumé of Progress in Insulation Research

**Steadily pioneering uncharted paths, the continuing efforts of those directing and participating in the uncovering and correlation of new knowledge in the field of dielectrics are laying foundations for the further development of electrical apparatus. A brief insight into some of these activities is given here.**

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As IN PRECEDING years, principal attention in this brief presentation is devoted to a survey of the literature of dielectrics and insulation as it has come to attention during the past year. Comments are based upon the reading of some 30 or 40 scientific papers, a list of which may be found at the close of this article. Since the topics vary over the whole field, from basic theory to large scale applications, the difficulty of a systematic division and the impossibility of anything more than a passing comment on the most important aspects of all this work may be appreciated.

## GASES

An important series of optical studies of the beginning of spark discharge is reported by Lawrence and Dunnington. Using a Kerr cell between crossed Nicol prisms, photographs of sparks $4 \times 10^{-8}$ sec after the application of voltage, as well as measurements of the broadening of spectrum lines and of the instantaneous current and temperature, have shown current densities of $1.7 \times 10^6$ amp per sq cm in the spark; have revealed inter-ionic fields of $10^6$ volts per cm, and the ionization of $1/3$ of the total number of molecules; and have shown temperatures of the order of 10,000 deg K in the spark. These results support Slepian's theory of thermal ionization.

By experiments in a uniform field Inge and Walther have studied the flashover of solid insulators. It is stated that flashover is always a breakdown of the air. This breakdown is influenced, however, by moisture or other condition of the solid surface, through auxiliary ionization and unequal potential gradient; clean, dry surfaces in a uniform field

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Essentially full text of a report presented to the fifth annual meeting of the N. R. C. committee on electrical insulation by Doctor Whitehead as its chairman, Baltimore, Md., Oct. 11, 1932.

flash over at the same voltage as the air when the dielectric is removed.

Interesting results on the decomposition of gases under electrical discharge are reported by Linder and Davis. Under glow discharge it is found that in a series of similar hydrocarbon compounds of increasing molecular weight the rate of gas evolution per unit current increases with the molecular weight, whereas in a series of the same molecular weight it increases with decreasing centralization. In another paper the ionization and dissociation of benzene and carbon-bisulphid under electron impact have been studied by spectrographic methods. Interesting data are recorded as to the nature and numbers of the resulting ions and conclusions are reached as to the stability of the bonds in the original molecule. These experiments have as their ultimate object the determination of information as to the chemical reaction in electrical discharges, with particular reference to the causes of the generation of gas in high voltage impregnated paper cables.

## LIQUIDS

The outstanding contribution in the field of liquid dielectrics is a series of 6 or more papers by A. Nikuradse, of the Technische Hochschule of Munich, concerning ionization, conductivity, and breakdown in insulating oils. These papers for the most part center about careful observations of the current-voltage curves under controlled conditions, and of similarly controlled breakdown tests over a wide range of frequency as related to the same oils. Good evidence is produced that the continuous current-voltage curve is of the same shape as that pertaining to gases. The saturation region is shown clearly, and in particular the ascending portion of the curve at higher voltages has been examined over a wide range of conditions. Temperature variations in the curves, and the increase of current with increased distance between electrodes, permit the computation of ionization coefficients and strengthen the theory of secondary ionization as the underlying cause of breakdown. In these experiments, purification was accomplished by drying, filtration, and successive distillation in an unusually elaborate experimental set-up. A definite residual conductivity always was found. The saturation phenomenon remains, and there are evidences of space charge of other polarity effects as related to the shape and materials of the electrodes. In the work on breakdown, one of the most striking features is the great increase in dielectric strength that may be reached by purification, this increase being of the order of from 100 to 1,000 times the values commonly attributed to good commercial insulating oils. The purer the oil, the less the influence of both pressure and temperature. For decreasing time of voltage application, the breakdown voltage for both pure and impure liquids approaches the same value, $1.3 \times 10^6$ volts per cm, at an impulse voltage of duration of the order $10^{-10}$. The influence that air in solution in an insulating oil has upon the behavior when electric stress is applied has been studied by Koppleman. Data on the relation to breakdown are submitted.

It should be noted that in this work Nikuradse has not studied the question of behavior under alternating stress except in the matter of breakdown. The continuous current-voltage relations are those pertaining to the long time or steady state. Current and loss relations under alternating stress are associated with an initial or short time value of conductivity that may be quite different to that observed in the steady state under continuous potential. The steady alternating behavior as related to this type of short time conductivity has been continued at Johns Hopkins using several highly refined and carefully protected oils of the commercial insulating group. It has been shown that in the low range of frequencies the losses and power factors of these oils are completely accounted for by an initial value of d-c conductivity having a duration of the order of one second. The conductivity is clearly ionic and there appears to be no reason to invoke any type of loss other than that due to the friction of ionic translation within the liquid.

Several studies of refined insulating liquids in small cells having as their object the correlation of molecular and electrical performance are known to be under way, but no important results have been reported during the year.

Action of cathode rays on hydrocarbon liquids has been studied by Schoepfle and Fellows, and in other experiments in the laboratories of the Detroit Edison Company. The gaseous products of several hydrocarbons under fixed conditions of bombardment are reported. Certain correlations have been found between the amount of gas and the molecular structure. Saturated hydrocarbons give large amounts of gas, whereas unsaturated hydrocarbons give small amounts of gas. Aromatic hydrocarbons give practically no gas. These experiments are directed particularly toward the conditions underlying the liberation of gas in high voltage cables, and seek information as to the relative stabilities of various oils under electric influence.

## SOLIDS

Most of the contributions in connection with solid dielectrics have a theoretical trend. P. Böning has continued his contributions expounding his theory of adsorption by colloid particles of the ions of one sign, and the passage to the electrodes of the ions of opposite sign, thus creating space charges and high values of potential gradient. The theory is developed particularly for liquid insulators, but is extended to include impregnated materials and others in which the liquid phase obtains to some extent. The most recent contribution deals specifically with the application of the theory of the behavior of impregnated paper, with particular consideration of space charge and potential gradient.

In a paper entitled, "What Is an Insulator?" Meissner proposes that the characteristic properties of insulators lie in the elementary crystal cell. The influence of the type of lattice, the nature of the bonds, and the intensities of the fields are discussed and correlated with experiments on piezo and pyro phenomena in crystalline and amorphous quartz.

The behavior of complex dielectrics also is discussed and the statement made that these, in general, if fused and allowed to solidify while under electric stress, also will show the pyro and piezo effects.

Debye's theory of molecular orientation as an explanation of dielectric loss in solid and semi-solid materials continues to be a topic of interest. An interesting series of experiments carried on by H. H. Race on electric and other physical properties of insulating oils, notably of oxidation and the spread of oil on water, support only partially the explanation of dielectric loss as a Debye effect. Oxidation increases the loss, but not the frequency at which maximum occurs. However, the spread on water is increased and this is an evidence of a polar property. A substantial loss factor remains after the computation of the Debye loss, indicating some other loss.

Measurements of dielectric constant and power factor of rosin oil and ethyl abietate in the range of frequency from 10 cycles to 100 kc and over the temperature range from $-65$ to $+20$ deg C, and other measurements made on certain glycols in the frequency range from 1 to 100 kc and with temperatures ranging down to $-90$ deg C have been made by White and Morgan. The particular interest of these substances is that their viscosity increases greatly within the temperature ranges mentioned, so that the anomalous dispersion or change of dielectric constant and also the maxima of power factor may be traversed into the measurements. Good agreement as between experiment and the Debye theory was found for a pure glycol, but some divergence in the case of a solution. Similar qualitative agreement was found by the same authors in rosin oil. At Johns Hopkins, experiments have shown that in the low frequency (60 cycles) range the observed variation in power factor and capacitance or dielectric constant with temperature may be accounted for in terms of a polarization arising first in the separation of space charges and later, as the solid phase is approached, in terms of the Maxwell dielectric absorption. So far as the losses in well known insulating liquids and in the more complex combinations for commercial insulation at 60 cycles are concerned, there seems to be general agreement that types of polarization other than that due to molecular orientation are well recognized, and under the Maxwell-von Schweidler theory of dielectric absorption are sufficient to account for the observed values of power factor and dielectric constant and their variations. If polar molecules are present, their contributions to these variations probably are small. At present, the most promising means of distinguishing between these two effects is to find a material in which there are two regions where the dielectric constant changes with frequency. In fact, Gemant has called attention to the fact that three such regions are to be expected, the third region being that of normal or optical dispersion due to the inertia of the charges within the body of the atom. Gemant places the range of frequency for the Maxwell-Wagner power factor maximum and corresponding anomalous dispersion at from 1 to $10^5$ cycles, whereas the Debye region is from $10^6$ to $10^{13}$, and the inner atomic region is around $10^{14}$ cycles.

The mechanism of the breakdown in solids has been discussed in an extensive paper by Joffé in which he includes brief accounts of many experiments which heretofore have been published only in Russian. They are now and will be in the future available in the Physikalische Zeitschrift der Sowjetunion, which is printed in German. Experiments are reported indicating that the breakdown voltages of natural, carefully tempered, and strongly deformed rock salt, colored by exposure to Röntgen rays, were found to be identical for impulse and continuous voltages, a result which the author feels proves that internal crystal cleavages have no bearing upon the mechanism of breakdown, just as the same author has shown that they have no influence upon the electric conductivity. Ionization by collision is studied in thin layers, in which case the ionization leads to a stationary current easily measured, instead of to breakdown. This peculiarity of thin layers is related intimately to their higher dielectric strength. As observed in mica and glass in layers 0.005 mm thick, dielectric strengths of $50 \times 10^6$ volts per cm were reached. The same phenomenon also was observed in pure gas-free liquids. Whereas, in thick layers, breakdown due to impulse or collision ionization is independent of the temperature, in thin layers the breakdown voltage is lowered with rising temperature until it reaches the thick layer value at the temperature of thermal breakdown. These facts lead to the conclusion that impulse ionization is caused by mobile ions and not in any way by electrons due to radio active influence. Nevertheless, it seems to indicate that an avalanche of ions leads to breakdown when the necessary initial conditions for thermal breakdown are present. The increased conduction due to ionization by collision, if not carried to breakdown, vanishes very quickly. In thin mica the recombination time is less than 0.003 sec.

## COMMERCIAL INSULATION

From a great deal of experimental and development work in this field, space limitations permit the mention of only 1 or 2 examples that are of particular significance. Gemant has proposed a new theoretical analysis of the rising power factor-voltage curve for impregnated paper containing gas layers. It is based upon the assumption that the breakdown of a thin air layer is limited to about 350 volts and that after breakdown the difference of potential over the air layer becomes zero and the ionization current stops. Further discharge can take place only by further increase of the applied over-all voltage or by its reversal. Thus, during the alternating cycle of maximum value just sufficient to cause breakdown, there will be 4 such breakdowns in one cycle. If the applied voltage is double or three times that necessary to cause the first breakdown, the number of discharges will be 8 and 12, respectively, etc. The author attempts a mathematical extension of this idea to the general case as based on thermal relations. The curves as derived agree generally with those observed, and the author claims that the usual power factor-voltage curve as measured may, by use of his formula, be used as an indication of the density of air layers within the insulation.

Whitehead and Baños, working with 10 different insulating oils, have shown that the dielectric loss in impregnated paper consists of 2 components, one due to conduction and the other to dielectric absorption; and further that a general relation exists between each of these components of loss, and the common physical properties of the impregnating oil. Baker and James have shown in qualitative manner the existence of soft X-rays and unequal potential distribution in impregnated paper. Wood and Brobst have reported the treatment of textile insulation with cellulose acetate, with resulting lowering of leakage conductance, the action apparently being due to the laying down of the fibers.

## HIGH VOLTAGE CABLES

A great deal of experiment and observation on cables, both in service and in laboratories, is being conducted by prominent utility companies. These studies have to do largely with the influence of temperature cycles on loss and power factor as related to stability, and in several instances are paralleled by accelerated life tests. Particular attention is being given to the performance of oil filled cables, and to the question of the possible reduction in thicknesses of insulation. Other questions receiving attention are a suitable aging test, the deterioration of impregnating oils under electric discharge, the thermal resistivity of insulation, and the imperfections of lead sheath due to corrosion and other causes. Reports of these various studies are commonly circulated within the N.E.L.A., the Association of Edison Illuminating Companies, and the bulletins of the Electrical Testing Laboratories. These reports are familiar to many persons, and as they are not published no attempt has been made to record them in detail in this report. An interesting survey of modern design, construction, and operation of high voltage cables will be found in a group of papers presented to the International Electrical Congress in Paris this last summer.

## MONOGRAPHS

While the issuance of another monograph has been impossible during the year just closing, substantial progress has been made toward the completion of further volumes in the series of monographs on dielectrics and insulation to be published under the auspices of the National Research Council's committee of electrical insulation. The first in the series, as may be remembered, was "The Nature of a Gas," prepared by Prof. L. B. Loeb of the University of California, Berkeley, Calif. The manuscript of the second in the series—"Liquid Dielectrics," by Dr. Andreas Gemant—is in hand and now is in process of preparation for publication. Progress is being made on 5 additional monographs:

Electric Discharge in Gases, by K. T. Compton and Irving Langmuir

Conduction in Gases, by J. Slepian and R. G. Mason

Solid Dielectrics, by C. F. Hill

Electrical Properties of Glass, by J. T. Littleton

Chemical Effects in Electric Discharge, by Geo. Glockler and S. C. Lind

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# Out-of-Step Conditions on a Synchronous System

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**During out-of-step conditions on a synchronous system, a state of equilibrium may be reached under which the system will neither accelerate nor retard until conditions are changed by switching operations, or by removal of synchronous condensers. Proof of this theory is given for a condition where the synchronous condensers were operating at 35 cycles (70 per cent of normal), the generators at normal speed of 50 cycles, and induction motors, with a load varying as the square of speed, operating at 65 per cent of synchronous speed.**

On SEVERAL OCCASIONS it was observed that when out-of-step conditions exist on the system of the Southern California Edison Company, Ltd., the synchronous condensers slow down to about 35 cycles per second and run at that speed until switched off the line or until operating conditions are altered in some other way. To determine the proper procedure for quick restoration of synchronism an actual out-of-step condition was exhaustively analyzed; the results of that analysis are given in this article. For some time several methods have been available for determining the power limits of a transmission system under steady state and transient conditions, but little is known of the behavior of systems when definitely out of step. The subject of system stability as presented up to this time has been treated as a problem of *maintaining* stability, whereas this article gives prime attention to the problem of *regaining* stability.

## SYNCHRONOUS POWER

The first step in evolving a method of solution was to consider the power equation of a synchronous machine:

$$P_m \sin \delta + P_r = P \qquad (1)$$

In this equation, which is accurate enough for the purpose involved, the terms representing electrical power are grouped on the left side of the equation and are equal to $P$, which is mechanical power. The term $P_m$ is the maximum synchronizing power that can be exchanged between the generator and the equivalent synchronous machine, which represents all the remaining synchronous machinery of the system. $P_r$ includes the internal losses and power supplied to resistance loads. Synchronism will be lost when the angle $\delta$ exceeds 90° and $P_m + P_r$ becomes equal to or less than $P$. From then on the synchronous power $P_m$ alternates from positive to negative. The net power applied to the rotating parts of the generating unit is equal to the algebraic difference of the 2 sides of eq 1. This is shown in Fig. 1.

In most cases $P_m$ is larger than $P_r$; hence when $\delta$ reaches the magnitude of 270° the left side of eq 1 becomes an input of power from the slower system to the faster generator. It can be shown that if $P$ could be made equal to $P_r$ during out-of-step conditions, the generator would continue to run at some average constant speed, but out of synchronism. Were $P$ reduced to a value lower than $P_r$ the generator would retard and eventually fall in step with the system. This reduction of $P$ is effected by the governor of the prime mover, but is not fast enough to prevent considerable disturbance of the system.

## INERTIA

However, eq 1 is true only under normal operating conditions and approximate for small deviations from synchronous speed. An important term has been omitted in the foregoing discussion that must be introduced into the equation when transients and out-of-step conditions are being investigated. The net power applied to the rotating parts of the generating unit has been mentioned already. Power applied to a rotating body having a certain angular

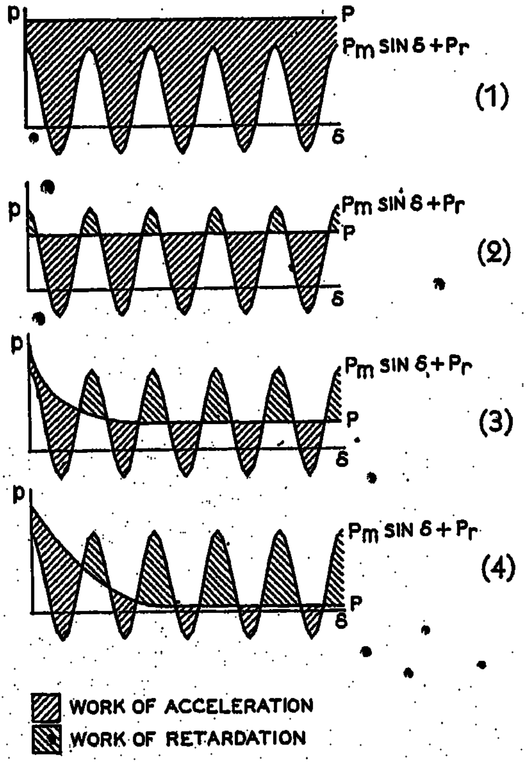

**Fig. 1. Input and output of a synchronous generator when running out of synchronism expressed as functions of angle between internal voltages of the generator and the combined synchronous machinery**

1. P larger than $P_m + P_r$
2. P smaller than $P_m + P_r$ but larger than $P_r$
3. P is made equal to $P_r$
4. P is made smaller than $P_r$

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Prepared especially for ELECTRICAL ENGINEERING. Written discussion is invited and will be published in so far as space and other controlling factors permit. *Not published in pamphlet form.*

momentum (sometimes called moment of momentum) will cause acceleration or retardation, depending upon the direction of the power applied. Either the generator or the system can be taken as a reference and a relative inertia term assigned to the other. Remembering further that the relative acceleration of the 2 is the second derivative of their angular displacement, eq 1 can be expressed as follows:

$$P_i \frac{d^2\delta}{dt^2} + P_m \sin \delta + P_r = P \qquad (2)$$

This equation represents synchronous machines with very little damping or induction motor characteristics; for transient stability calculations at or near synchronous speed, it is being used in this form or its equivalent in torque terms.

### INDUCTION MACHINE CHARACTERISTICS

Synchronous machines have some damping as an inherent characteristic in addition to the damping introduced into their design to stabilize them in operation and to improve their starting characteristics. Damping is equivalent to the induction machine characteristics that exist in the field structure of the synchronous machine. A certain amount of damping is introduced by the field circuit itself when completed through the armature of the exciter, by the damper windings when present, and by the iron of the field structure. As in induction machines, the power due to damping is a function of terminal voltage and difference of speeds or the first derivative of angular displacement. By introducing the damping term in eq 2 the following equation is obtained:

$$P_i \frac{d^2\delta}{dt^2} + P_d \frac{d\delta}{dt} + P_m \sin \delta + P_r = P \qquad (3)$$

This is the general equation of a synchronous machine and its development is described by W. V. Lyon and H. E. Edgerton, in their paper "Transient Torque-Angle Characteristics of Synchronous Machines" (A.I.E.E. TRANS., v. 49, April 1930, p. 686–99.)

### OUT-OF-STEP OPERATION

Unfortunately eq 3, which is a differential equation, has not been solved; that is, presented in the form

$$\delta = f(t) \qquad (4)$$

Were such a solution available, all stability and out-of-step problems could be solved easily in terms of time. As it stands, problems of this kind must be dealt with by making various assumptions and approximations, or by making long and tedious step-by-step calculations.

The assumption which led to the method of calculation of out-of-step operation now will be discussed. As was observed in actual operation, the difference in speeds of generators and condensers was constant for a period of minutes. This being the case, the angle $\delta$ was assumed to be a straight line function of time $(Kt + \delta_o)$:

$$P_d K + P_m \sin (Kt + \delta_o) + P_r = P \qquad (5)$$

The average can be found by integrating with respect to $dt$ between limits of $O$ and $\frac{2\pi}{K}$ and dividing by $\frac{2\pi}{K}$. The final equation will be

$$P_d K + P_r = P \qquad (6)$$

Equation 6 can be interpreted to mean that when a synchronous generator is out of step, and running at constant speed, the synchronizing power is pulsating and the average value is zero. The input then must be equal to the total of losses, resistance loads, and output as an induction generator. When a condenser or synchronous motor is out of step and running at a constant speed the mechanical output, losses, and electrical output due to internal voltage must be equal to the input as to an induction motor.

The assumption of $\delta$ being a straight line function of time is not correct in a strict mathematical solution, but a substitution of typical numerical values and a step-by-step solution would demonstrate the permissibility of that assumption, because the result is quite accurate for practical purposes.

### METHOD OF COMPUTATION

When machines of different characteristics are connected to the same system and are out of step, 2 or more frequencies are imposed on the system. The method of analyzing a condition of this kind is discussed in the following paragraphs.

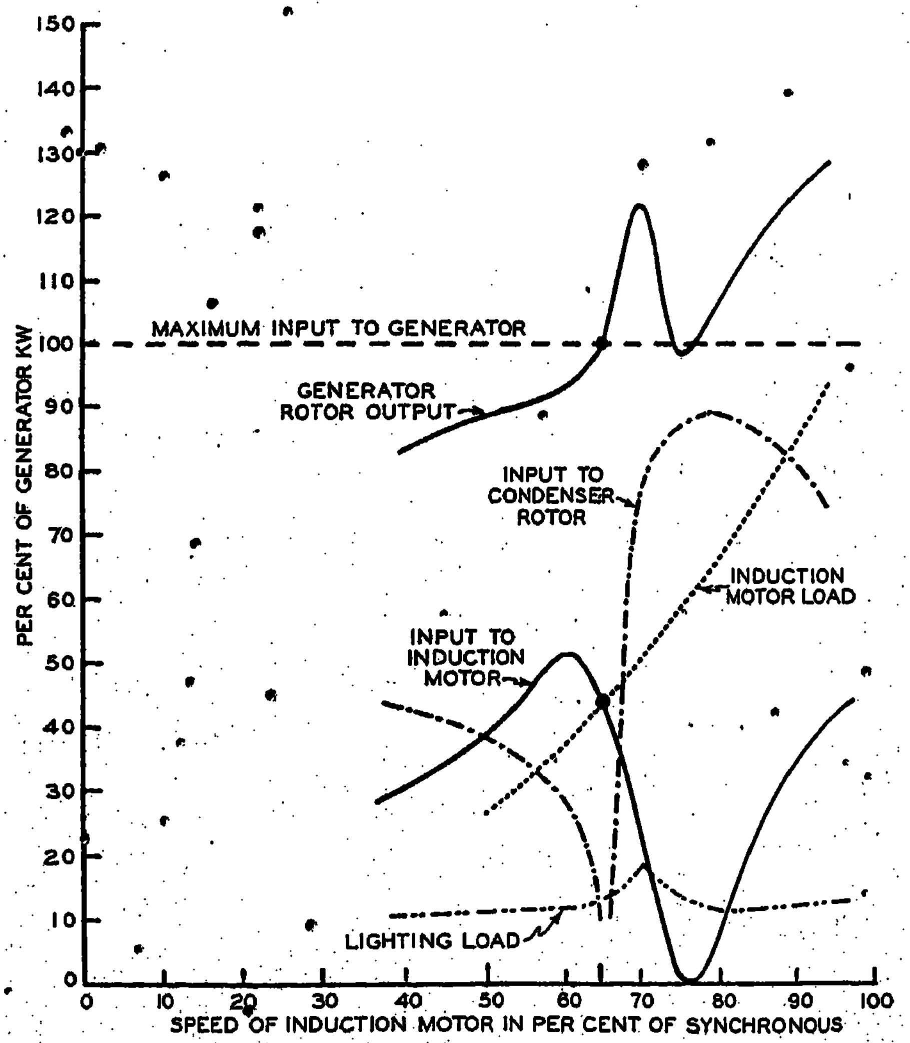

**Fig. 2. Power input and output of machines expressed as functions of speed of induction motor**

System consists of 200,000 kw of steam generating capacity, 240,000 kva of synchronous condensers, 190,000 kw of induction motor load, and 50,000 kw of resistance load. The generators are operating at normal speed while the condensers are operating at 70 percent of synchronous speed

Consider a simple system composed of a generator, a short transmission line, a synchronous condenser with damper windings, an induction motor with a load varying as the square of its speed, and some resistance or lighting load. The generator is running at 50 cycles, the condenser at 35 cycles. The problem is to determine the speed of the induction motor and the power flow in the circuits. To do this, the 2 synchronous machines are considered as consisting of an ideal synchronous machine solidly coupled mechanically to an induction machine having characteristics similar to those of the original machine. Under normal synchronous operation both component machines would be connected to the same circuit and the induction part would be driven at synchronous speed with respect to the system thus having zero power output, but during out-of-step conditions 2 systems must be considered. One of these is a 50-cycle system composed of the synchronous generator supplying power to the induction motor characteristics of the synchronous condenser which is operating at a 30 per cent slip, in addition to the power required by the induction motor and resistance load; the other, a 35-cycle system composed of an induction generator operating at 43 per cent positive slip and supplying power to the induction motor and resistance load by virtue of the fact that the induction characteristics of the synchronous generator receive excitation from the synchronous condensers at 35 cycles. Power inputs and outputs of the units in both systems can be computed and the results superposed. The results then are plotted as functions of induction motor speed.

In Fig. 2 are shown results of computations of a condition experienced on a portion of the system of the Southern California Edison Company, Ltd., after an out-of-step condition had occurred and the system had been separated into 3 independent sections. The section under consideration included 200,000 kw of steam-electric generating capacity, 240,000 kva of synchronous condensers, a normal 190,000 kw of induction motor load, and 50,000 kw of resistance load. The speed of the generators at the time represented in Fig. 2 was normal, but that of the condensers was observed to be but 70 per cent of normal, or 35 cycles per second. As may be seen from Fig. 2 the induction motor was running at about 65 per cent of synchronous speed, as the dual frequency input at that speed balanced the load. The induction motor load under these conditions amounted to 44 per cent of generator input or 88,000 kw, the lighting load amounted to 12 per cent of generator input or 24,000 kw, and the bus voltage was 69 per cent of normal. The remainder of the generator input was absorbed in generator, transformer, line, and condenser losses. The generators were carrying full load and could not develop any additional power to accelerate either the condensers or the induction motors. The induction motors did not slow down because at lower speeds their input would have exceeded their load.

With conditions of this kind established on the system it is necessary to switch the condensers off until after the induction motors are accelerated to normal speed with respect to the generators. Then the condensers can be resynchronized. If the system be allowed to operate for any length of time under conditions like those just described the condenser and generator damper windings and field structures will overheat rapidly and eventually burn out.

## DETAILS OF CALCULATION

Some of the details of calculating out-of-step conditions are indicated in the following brief outline.

Nomenclature:
$E_1$ —internal voltage of generator
$E_2$ —internal voltage of condenser
$\dot{Z}_1$ —impedance of generator to bus
$\dot{Z}_2$ —impedance of condenser to bus
$V$ —bus voltage
$R$ —resistance shunt
$\dot{Z}_1''$—impedance of equivalent induction generator driven at $f_1$ cycles on an $f_2$-cycle bus
$\dot{Z}_3'$—impedance of induction motor at speed $S_3$ on an $f_1$-cycle bus
$\dot{Z}_3''$—impedance of induction motor at speed $S_3$ on an $f_2$-cycle bus
$\dot{Z}_2'$—impedance of synchronous condenser at speed $f_2$ cycles on an $f_1$-cycle bus
$\dot{Y}'$ —total admittance of circuits at $f_1$ cycles from air gap of generator
$\dot{Y}''$ —total admittance of circuits at $f_2$ cycles from air gap of synchronous condenser

There will be 2 electromotive forces in the circuit. If $f$ is the normal frequency,

$$E_1' = \frac{f_1}{f} E_1 \quad \text{and} \quad E_2'' = \frac{f_2}{f} E_2$$

The generator output will be

$$P_1 + jQ_1 = \frac{f_1}{f} \dot{E}_1 \dot{V}' \dot{Y}' - \frac{(V'')^2}{\dot{Z}_1''}$$

Condenser input (or output)

$$P_2 + jQ_2 = \frac{f_2}{f} \dot{E}_2 \dot{V}'' \dot{Y}'' - \frac{(V')^2}{Z'_2}$$

Induction motor input

$$P_3 + jQ_3 = \frac{(V')^2}{\dot{Z}_3'} + \frac{(V'')^2}{\dot{Z}_3''}$$

Resistance load

$$P_4 = \frac{(V')^2 + (V'')^2}{R}$$

Bus voltage

$$\frac{\dot{V}' = \frac{f_1}{f} E_1 - \left(\frac{f_1}{f}\right)^2 E_1 \dot{Y}' Z_1}{\dot{V}'' = \frac{f_2}{f} E_2 - \left(\frac{f_2}{f}\right)^2 E_2 \dot{Y}'' \dot{Z}_2}$$

The problem then consists in evaluating the impedances and admittances of the circuits, using all available data on machinery or making reasonable assumptions.

Generator input $= P_T$ (constant)
Motor load $= P_L S_3^2$ where $P_L =$ coefficient.

## PROOF OF SUPERPOSITION PRINCIPLE

If 2 frequencies having a ratio $r$

$f_1/f_2 = r$

are considered and expressions for instantaneous voltage and current in one phase to ground of the circuit are written

$$e_1 = E_1 \sin (r\omega t)$$
$$e_2 = E_2 \sin (\omega t)$$
$$i_1 = I_1 \sin (r\omega t + \theta_1)$$
$$i_2 = I_2 \sin (\omega t + \theta_2)$$

the powers (1 phase) are

$$P_1 = \frac{1}{2} E_1 I_1 \cos \theta_1$$

$$P_2 = \frac{1}{2} E_2 I_2 \cos \theta_2$$

and it is to be proved that

$$P_R = P_1 + P_2$$

The resultant voltage and current in the circuit are

$$e_R = E_1 \sin (r\omega t) + E_2 \sin (\omega t)$$
$$i_R = I_1 \sin (r\omega t + \theta_1) + I_2 \sin (\omega t + \theta_2)$$

and the instantaneous power is

$$P_R = e_R i_R = [E_1 \sin (r\omega t) + E_2 \sin (\omega t)] [I_1 \sin (r\omega t + \theta_1) + I_2 \sin (\omega t + \theta_2)]$$
$$P_R = E_1 I_1 \sin (r\omega t) \sin (r\omega t + \theta_1) + E_2 I_2 \sin (\omega t) \sin (\omega t + \theta_2) + E_1 I_2 \sin (r\omega t) \sin (\omega t + \theta_2) + E_2 I_1 \sin (\omega t) \sin (r\omega t + \theta_1)$$

Remembering that

$$\sin \alpha \sin \beta = \frac{1}{2} \cos (\alpha - \beta) - \frac{1}{2} \cos (\alpha + \beta)$$

we now have

$$2P_R = E_1 I_1 \cos \theta_1 + E_2 I_2 \cos \theta_2 - E_1 I_1 \cos (r\omega t + \theta_1) - E_2 I_2 \cos (\omega t + \theta_2) + E_1 I_2 \cos (\theta_2 + (1 - r)\omega t) - E_1 I_2 \cos (\theta_2 + (1 + r)\omega t) + E_2 I_1 \cos (\theta_1 + (1 - r)\omega t) - E_2 I_1 \cos (\theta_1 + (1 + r)\omega t)$$

The average value of power is

$$P = \frac{1}{T} \int_0^T ei dt$$

Let $O$ and $T$ satisfy the equation

$$\sin (\omega t) = \sin (r\omega t) = 0$$

and integrate the expression for $2P_R$. The process of integration is too complicated to show here, but the result is

$$2P_R = E_1 I_1 \cos \theta_1 + E_2 I_2 \cos \theta_2$$

and

$$P_R = \frac{1}{2} E_1 I_1 \cos \theta_1 + \frac{1}{2} E_2 I_2 \cos \theta_2$$

which is

$$P_R = P_1 + P_2$$

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2. ALTERNATING CURRENTS (1921), C. E. Magnusson, Chapters XIII and XXIII.
3. SYSTEM STABILITY AS A DESIGN PROBLEM, R. H. Park and E. H. Bancker, A.I.E.E. TRANS., v. 48, Jan. 1929.

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# A Theory of Neon Tube Operation

**Here is advanced a theory of luminous tube operation based upon an engineering study of the voltage and current waves associated with the discharge of electricity through neon gas.**

By
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ASSOCIATE A.I.E.E. Fort Wayne, Ind.

SUCCESSFUL OPERATION of the popular cold cathode neon tube lighting system depends upon many factors, some of which are quite intricate and intangible. In this system a transformer which may have 97 per cent reactance and a secondary potential as high as 15 kv is used as a source of supply. The theory of operation of this system may be generally unknown, and it is the purpose of this article to promote a theory from an engineering standpoint based upon a study of the voltage and current waves associated with the discharge through the neon gas.

In its normal state neon gas is a relatively good insulator, but when ionized the gas becomes a conductor with a negative resistance characteristic. This means that the lower the voltage drop across a given length, the greater the current that flows through the gas. A volt-ampere curve of one particular type of neon tube is shown in Fig. 1. If the symbol $e_t$ represents the instantaneous value of voltage it can be expressed as some function of the current, thus

$$e_t = f(i) \qquad (1)$$

If a sinusoidal current wave passing through the gas be assumed, and if from the instantaneous values of current are found the corresponding values of voltage, the wave form of voltage necessary to produce this current can be determined. Such a wave form is shown in Fig. 2. It is not feasible, however, for a sine wave of current to flow through the neon gas because the ionization potential as shown in Fig. 1 is higher than the voltage necessary to maintain a current flow. The potential at the beginning of each half-cycle must rise to a value sufficiently high for ionization, then reduce to some value indicated by the curve in Fig. 1. It is evident that the current

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Written especially for ELECTRICAL ENGINEERING. Based upon a paper originally read before the A.I.E.E. Fort Wayne, Ind., Section, this article supplements the information concerning luminous tubes as given in the articles published in ELECTRICAL ENGINEERING in August and November 1931. *Not published in pamphlet form.*

ust remain at zero for a short period of time during ach half-cycle, and as a result the wave form is more eaked than a sine wave. The actual wave form of urrent and voltage is shown by the oscillogram in ig. 3 which was obtained from a circuit employing a sistance instead of a reactance for limiting the urrent. This establishes 2 important facts: (1) at the current wave crosses the zero axis inside the

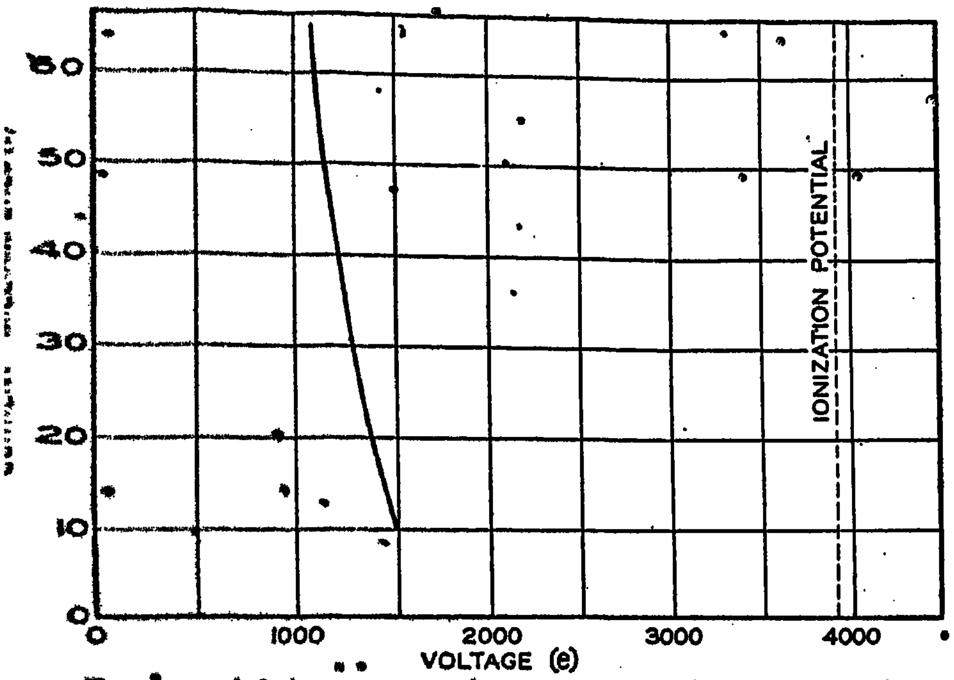

Fig. 1. Volt-ampere characteristics of one type of neon tubing including electrode and gas column

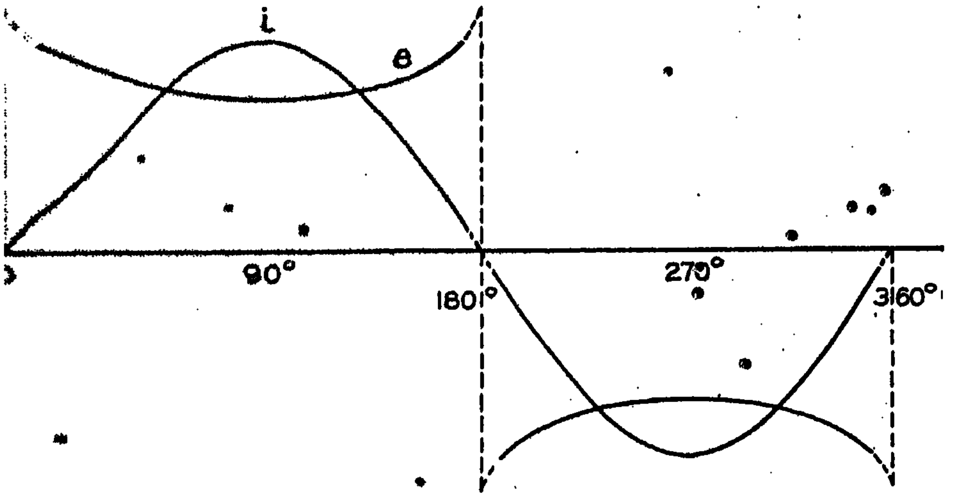

Fig. 2. Voltage wave (e) calculated from Fig. 1 assuming sinusoidal current (i)

nvelope of voltage wave, and in this respect the eon tubing acts as a resistance load requiring eaked current; (2) during each half-cycle the current actually is zero for a finite length of time.

Consider a high reactance transformer as repreented by the circuit in Fig. 4 which shows the rectance of a transformer concentrated in an inducance $L$ in the secondary circuit. Neglecting the esistance drop in both the transformer and the xternal inductance the voltage across the resistance oad may be represented by the equation

$${}_R = E_s - E_L \text{ vectorially} \qquad (2)$$

In eqs 1 and 2 the symbols $E$ indicate rms values. f instantaneous values are considered,

$$\begin{aligned} {}_R &= e_s - e_L \\ &= e_s - L\frac{di}{dt} \end{aligned} \qquad (3)$$

The vector and wave-form diagrams of Fig. 5 may represent, respectively, eqs 2 and 3, and from these diagrams it is clearly evident that the load voltage lags the induced or open circuit voltage by some angle $\phi$. If the load is of such a nature that a peaked current wave is established throughout the circuit, the differential of this current wave represented by $L\frac{di}{dt}$ will be a flat topped wave. When this flat voltage wave is subtracted from the open circuit voltage $e_s$ the load voltage wave $e_R$ also will be a flat topped wave as shown in Fig. 6. Thus it is possible for the current to assume such a form that the load voltage wave will be somewhat similar to that shown in Fig. 2 and therefore suitable for operating a neon tube load, at least for a portion of each half-cycle. When a neon tube load is substituted for a resistance load, the symbol $e_t$ should be substituted for $e_R$ in eqs 2 and 3. Thus there are 2 equations (1 and 4) which must be satisfied by the same value of current:

$$e_t = f(i) \qquad (1)$$

$$e_t = e_s - L\frac{di}{dt} \qquad (4)$$

When the neon tube load is placed across the secondary of the transformer the current follows a periodic variation. The instantaneous values of current not only must give some specific value of $e_t$ represented by eq 4, but the same instantaneous value of current must give the same value of $e_t$ when taken from the curve in Fig. 1 or from eq 1. The actual wave form of current, therefore, will be a compromise between a peaked wave and a sine wave.

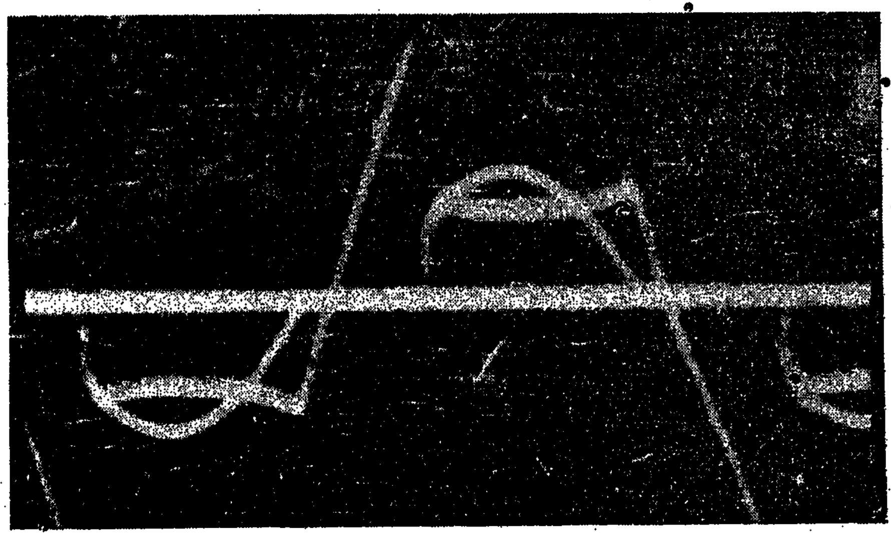

Fig. 3. Oscillographic record of current (a) in and voltage (b) across a section of neon tubing with current limited by resistance

Considering again the circuit which has wave form characteristics as indicated in Fig. 6, suppose the initial condition is open circuit, when only the voltage $e_s$ exists; then let a load suddenly be applied and, for simplicity, assume that no oscillatory phenomena are involved. The terminal voltage must change from the open circuit wave form to the load voltage wave form which requires not only a change in magnitude, but also a change in phase relation.

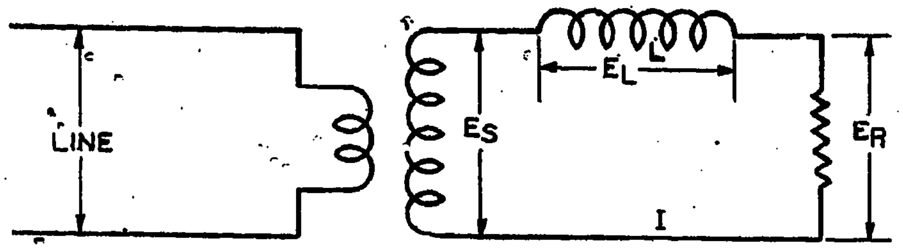

Fig. 4. Circuit diagram of a high reactance transformer with leakage reactance concentrated in a series inductance (L)

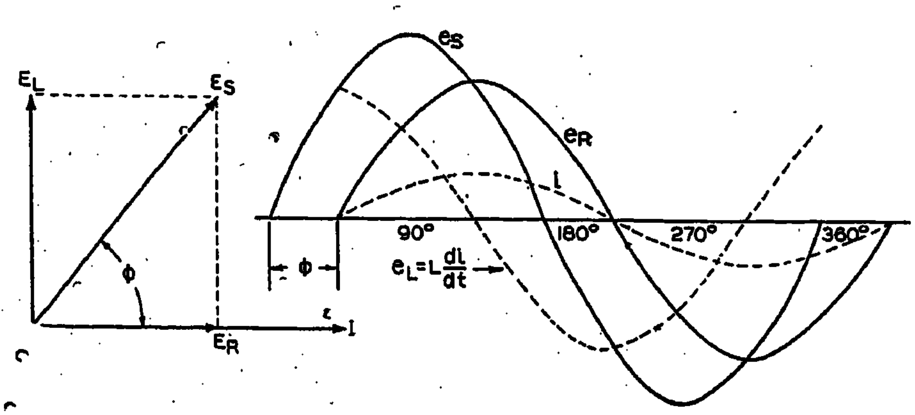

Fig. 5. Vector (left) and wave form (right) diagrams showing the relation of voltages for a high reactance transformer supplying a resistance load

Likewise, when the load is removed suddenly the voltage must transfer from the load voltage condition to that of open circuit voltage wave form. The terminal voltage will follow some form as generally indicated in Fig. 7. By further reference to Fig. 3 it is evident that, since the current is zero for an appreciable time during each half-cycle, the load is equivalent to one which is applied and removed at the beginning and end of every half-cycle.

Now, the general wave form of voltage across the terminals of a neon tube may be derived. If it be assumed that the neon tube load is applied to the transformer at the instant when $e_s$ crosses the zero axis the voltage will rise along the open circuit wave until ionization occurs. After this value of voltage is reached the flow of current causes the voltage to drop rapidly to the load voltage wave form. This rapid decrease in voltage causes the current through the neon gas to increase to a greater amount; but an instant later the voltage will rise along the load voltage wave form, which rise must be accompanied by a decrease in current through the neon gas. This process is contrary to the normal tendencies of the current, which attempts to maintain a sinusoidal wave form. From the standpoint of eqs 1 and 4, the current flow during the initial portion of each half-cycle will not satisfy both these equations because of this unstable phenomenon which causes the voltage and current to continue to oscillate until finally a stable state is maintained. This general process is shown in Fig. 8. At the end of each half-cycle the load is removed and hence the voltage returns to the open circuit position which by this time already has crossed the axis and may be of sufficient magnitude in the opposite direction to cause instant reionization of the gas for the next half-cycle. In Fig. 9 is shown a cathode ray oscillogram of the unstable portion of a half-cycle. From this oscillogram one may come to the conclusion that the oscillatory period is similar to a damped oscillation which finally terminates in a stable condition.

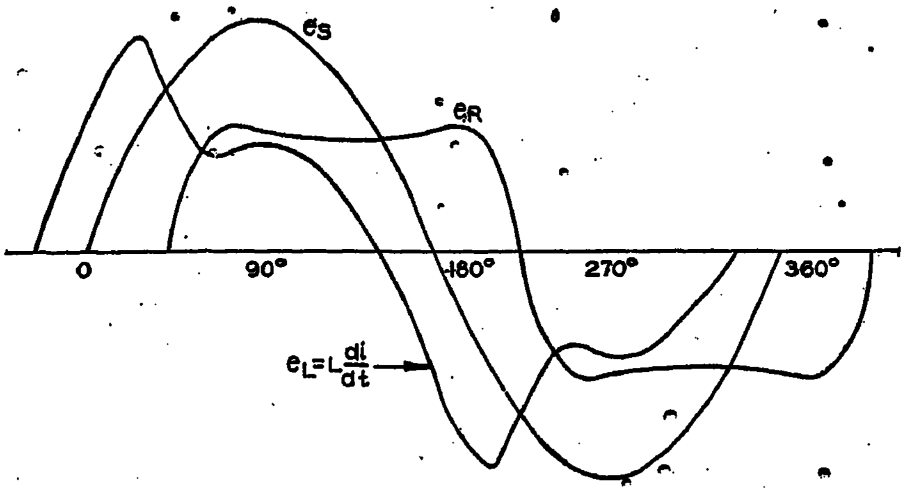

Fig. 6. Voltage wave forms for a high reactance transformer supplying a load requiring a peaked current wave

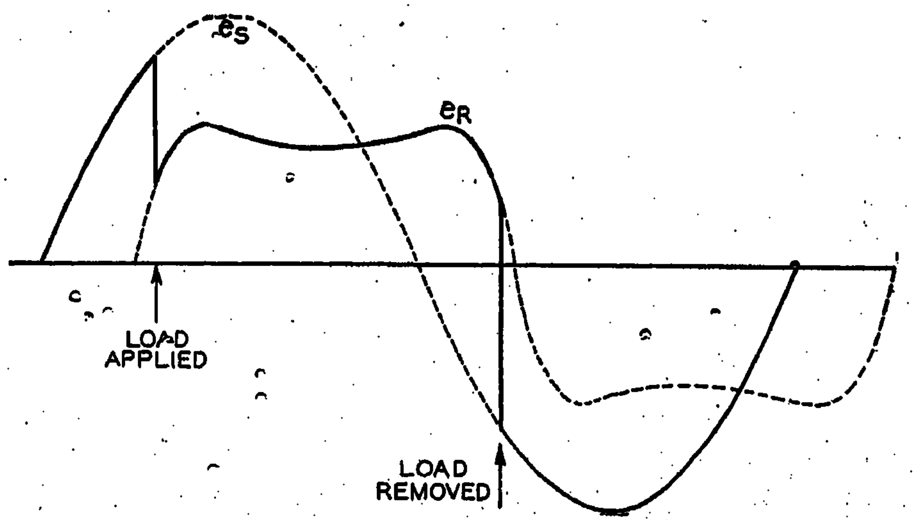

Fig. 7. Voltage wave form for a high reactance transformer supplying an intermittent load requiring a peaked current wave

When the length of tubing is increased the position of $e_i$ in Fig. 8 and the ionizing potential shift to a higher value. It is possible to add such a length of tubing that at no time during the half-cycle will the current satisfy eqs 1 and 4, and the result is a continued oscillation throughout the entire half-cycle. This unstable phenomenon is accompanied by the appearance of a series of dark spaces (referred to as "beads") in the illumination emitted by the neon gas. By still further increasing the length of tubing the ionization potential may be increased to a value corresponding to the maximum value of the open circuit voltage wave. Occasionally this open circuit voltage may be insufficient to produce ionization, and for an entire half-cycle or longer no illumination will be produced. Such a condition is the cause of flicker. During this period the voltage simply follows the open circuit wave form until ionization is produced again, which may or may not be on the next succeeding half-cycle. In Fig. 10 is shown an oscillogram, made with a mechanical oscillograph, that represents the wave form of voltage showing 3 conditions: flicker, beads, and stable operation. A wave representing what the open circuit voltage would be if there were no tubing connected to the transformer also is shown on the oscillogram. Too great a length of tubing places a severe strain on the transformer, especially if beads occur, because the high frequency oscillations are prolonged for an entire half-cycle and the peaks of these oscillations are near the peak of the open circuit voltage wave form.

Occasionally it happens that one user of a neon sign obtains better performance than another having the same type of transformer and the same kind and length of tubing. This difference in operation may be explained by the fact that the amount of capacitance from the tubing to ground may be different in the 2 installations. When a capacitor is placed across the terminals of a high reactance transformer the voltage is raised above the open circuit value. If the capacity is small, however, the amount of boost in voltage is small on open circuit, but with a neon tube load this capacitance is effective. The reason for this is that the rapid change in voltage at the end of each half-cycle, as shown in Fig. 8, is equivalent to a very high frequency under the influence of which the capacitor becomes effective in boosting this peak above the open circuit value. This is especially true for long lengths of tubing for which the ionization potential is near the peak of the open circuit voltage. By purposely adding capacity to the circuit, a greater length of tubing can be operated from a given transformer, but this is because the voltage rises above the open circuit voltage at the beginning of each half-cycle and therefore is undesirable from a standpoint of transformer life. To obtain successful operation from the transformer as well as from the neon tubing it is essential to operate the transformer with a length of tubing considerably shorter than that which will produce flicker or beads.

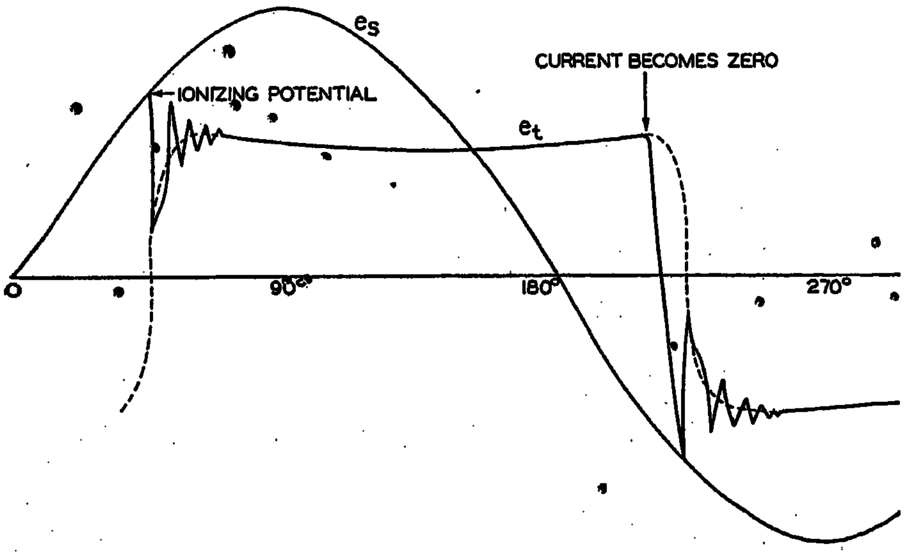

Fig. 8. Wave form of the load voltage across a neon tube

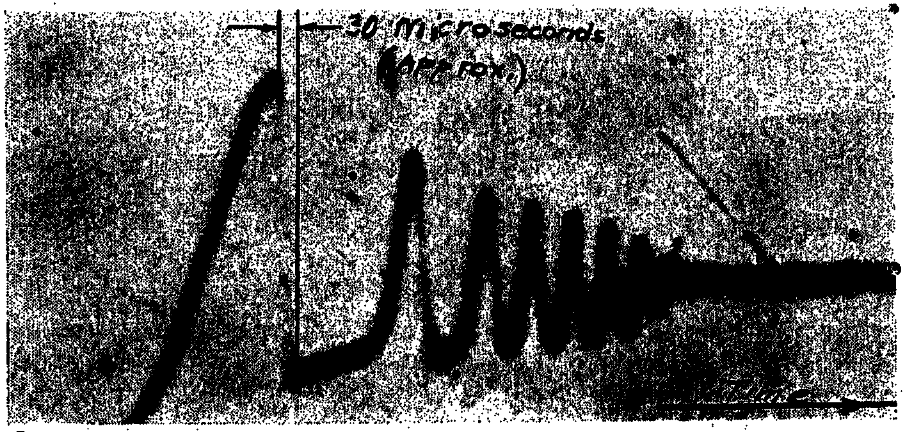

Fig. 9. A cathode ray oscillogram of a portion of one half-cycle of a neon tube voltage wave showing how the unstable portion is attenuated

Some of the most important factors affecting the operation of a neon lighting system arise from the characteristics of the tubing itself. Such factors as gas pressure; impurities in the gas; size, shape, and number of electrodes; diameter of tubing; and kinds of gases used to produce various colors have some influence upon the ionizing potential of a given length of tubing and upon the shape of its volt-ampere characteristic curve. One may realize that a change in the shape of the curve of Fig. 1 will influence eq 1; hence the duration of the unstable period of each half-cycle, and the magnitude and frequency of the oscillations during this period, will be different for each different type of tubing. A transformer of some specific rating may operate 70 ft of one type of tubing, whereas the same transformer might be under a more severe strain if loaded with only 40 ft of some different type of tubing, because of the possible occurrence of high frequency oscillations and of peaks higher than the open circuit voltage.

In the foregoing discussion many factors have not been considered; such as change in ionization potential with temperature of electrode, change in volt-ampere characteristics with temperature, deionization time of neon gas and others. No doubt many of these items should be taken into consideration in order to offer a complete explanation of the wave forms of voltage and current observed. However, the important point to bear in mind is that a study of the voltage and current wave forms of neon tubing presents a much clearer picture of the physical operation of this system of illumination than otherwise would be possible.

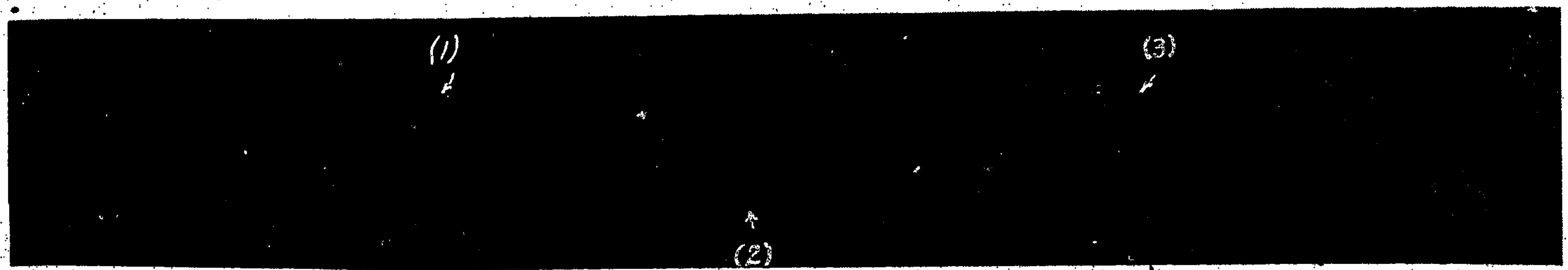

Fig. 10. Oscillogram of voltage across a neon tubing showing (1) a stable half-cycle, (2) a flicker period, (3) instability throughout one entire half-cycle

# Experience With Supervisory Control

**The Reading-Philadelphia suburban electrification has afforded a thorough trial of supervisory control equipment in actual operation. The experiences which have been secured with this equipment and which demonstrate its numerous advantages are described in this article.**

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ALL substations and switching stations for the Reading-Philadelphia suburban electrification are non-attended and operated by supervisory control. This type of control was selected on the basis of flexibility, speed with which the system can be cleared at the time of fault, freedom from error, concentration of operation at one point, elimination of divided responsibility, and economy. Two men maintain the equipment which is installed in 21 stations. There has been no trouble experienced from induction, no faulty operations have been performed, no faulty indications have been given and not a single train delay has been caused by failure of the supervisory control equipment. Each benefit attributed to the equipment has been fully realized in operation, proving the adequacy of supervisory control for operating an electrified railway.

The power dispatcher's office is located at Wayne Junction, 5 miles from Reading Terminal, Philadelphia, Pa., as this is the junction of several branch lines and the location of the railroad's main substation. Here also, is the Philadelphia Electric Company's frequency-changer station which supplies the 25-cycle power for the electrification. Train dispatchers are located at Reading Terminal and a special telephone line connects the train dispatcher's office with the power dispatcher's office.

From his office at Wayne Junction the power dispatcher operates the entire system with supervisory control; he controls 8 main substations and 13 switching stations, including control and supervision of 255 points over 4 supervisory control systems, utilizing 4 sets of line wires. Table I indicates the various systems and summarizes the number of stations and control points on each set of line wires, one set of line wires being required for each system. It is of particular interest to note that on the Wayne Junction-Lansdale system there are 11 stations, all operated over the same set of line wires.

### Table I—Summary of Supervisory Control Equipment

| Station | Number of Points | Dist. from Disp. Office (Miles) |
|---|---|---|
| System A—Wayne Junction to Reading Terminal—Westinghouse "Visicode" | | |
| Race Street | 24 | 5.3 |
| *Reading Terminal | 6 | 5.0 |
| Brown Street | 7 | 4.4 |
| 16th Street Junction | 10 | 1.9 |
| "WS" Tower | 7 | 0.6 |
| System C—Wayne Junction to Lansdale and Hatboro—Westinghouse "Visicode" | | |
| Newton Junction | 4 | 0.9 |
| Tabor Junction | 3 | 1.6 |
| Elkins Park | 7 | 4.0 |
| "DB" Tower | 4 | 6.0 |
| Glenside | 5 | 6.7 |
| Roslyn | 4 | 8.7 |
| *Hatboro | 5 | 13.2 |
| Oreland | 6 | 8.4 |
| *Ambler | 20 | 11.7 |
| Gwynedd Valley | 5 | 14.8 |
| *Lansdale | 21 | 19.0 |
| System D—Wayne Junction to West Trenton—Westinghouse "Visicode" | | |
| *Jenkintown | 32 | 5.8 |
| Roelofs | 7 | 23.1 |
| *Yardley | 24 | 25.2 |
| System E—Wayne Junction to Neshaminy Falls—General Electric "Synchronous Selector" | | |
| *Bethayres | 20 | 9.7 |
| *Neshaminy Falls | 34 | 15.6 |
| **System B—Wayne Junction to Chestnut Hill—Westinghouse "Visicode" | | |
| Wister | 4 | 1.0 |
| Sedgwick | 5 | 3.6 |
| *Chestnut Hill | 16 | 5.7 |
| **System F—Wayne Junction to Norristown | | |
| Manayunk | 3 | 5.0 |
| Conshohocken | 3 | 11.0 |
| Ivy Rock | 2 | 12.4 |
| *Norristown | 21 | 14.7 |
| Total—Present | 255 | |
| Total—Future | 309 | |

* Transformer substation.
** Equipment under construction.

The supervisory control systems provide the dispatcher with the following operating features:

1. Control and indication on all circuit breakers and motor-operated trolley sectionalizing switches.
2. When an automatic operation occurs, an alarm bell is sounded, proper indication of the position of the unit is given, and a disagreement lamp indicates which unit has operated.
3. An alarm is sounded and an indication is given if any substation battery voltage reaches a predetermined low value; indication is also given when the battery voltage returns to normal.
4. An alarm is sounded and an indication is given if the temperature of any power transformer on the system reaches a predetermined high value; indication is also given when the temperature returns to a safe operating value.
5. All substation bus differential lockout relays are electrically reset by supervisory control.

## OPERATING EXPERIENCE

In the first 6 months of operation there have been several cases of low battery voltage indicated; in each case a maintenance man was sent to the station to make repairs and no serious trouble developed.

During the same period there was one bus differential relay operation which appeared to have been faulty. This occurred during the morning rush hour. The power dispatcher reset the lockout relays and reclosed the breakers, all of which re-

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Full text of "Operating Experience With Supervisory Control on the Reading-Philadelphia Suburban Electrification" (No. 32M14) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20-24, 1932.

ained closed. No train delays were involved. On he other hand, had it been necessary to send a man o the station, serious train delays would have een caused at a most strategic hour.

The line wires are carried in a jute armored comunication cable installed along the railroad rightf-way, which is used jointly for railroad telephone nd telegraph circuits and supervisory control. To uard against line wire trouble a completely conected spare set of line wires has been provided for ach system and the power dispatcher can transfer rom one set to the other by merely pressing a button r throwing a switch on the control desk. There ave been no cable failures; however, several cases f open line wires have occurred due to poor conections to terminals but there has been no time uring which trouble was experienced on both sets f line wires simultaneously.

A thorough study was made to determine the ffect of induction upon the operation of the superisory control equipment, also of methods of drainng the induced current. On the 2-wire "visicode" ystems the drainage consists of a resistance conected between each line wire and ground and on the -wire "synchronous selector" system a resonant rain is employed, consisting of a condenser in series vith a reactor connected between each line wire and ground. In both systems, vacuum type protector ubes which are self-recovering when the high voltage is reduced, protect the line wires from voltage n excess of 300 volts caused by a cross with a high voltage circuit, from lightning or from an exceedingly severe short circuit. Fuses and carbon type protector blocks used on the railroad telephone and telegraph lines are not used on the supervisory control line wires in order to eliminate the possibility of open circuits and grounds. Operating experience has indicated that the drainage employed is adequate and that there have been no failures caused by induction.

## INSTALLATION, TESTING, AND MAINTENANCE

Installation and testing of the supervisory control equipment offered no serious problems, the entire installation being carried out by the Reading Company's electrification forces. There were a few minor difficulties encountered during the testing period, such as trouble from blown fuses and necessity for readjusting relays which were altered during shipment. Tests consisting of load and short-circuit induction were conducted to determine the efficacy of the drainage equipment. Load induction was simulated by tying the trolley to the rail at the end of the line. The voltage then was raised until the desired current was circulating. Current up to 1,500 amperes was stub fed over 14 miles of trolley rail circuit, and no difficulties in the operation of the supervisory control equipment were experienced. Further, no trouble occurred when full-voltage short circuits were applied at the end of the line fed in the same manner. Following the induction test, power system tests were conducted throughout the entire electrification territory and whenever possible test setups were made by the power dispatcher with supervisory control and all indication of circuit breaker operations given by the supervisory control were checked. Any difficulties arising were immediately analyzed and corrected. The thoroughness of the tests applied prior to the starting of revenue service undoubtedly has helped to effect the creditable operation of the equipment.

At an early date it was realized that the maintenance of the supervisory control equipment would require a skilled man capable of tracing the circuits and adjusting telephone type relays. The railway company employed a man and gave him every opportunity to become thoroughly familiar with the equipment. He remained at the factory during its construction and inspection, following closely the installation and finally the testing. Since the entire system operation is dependent upon the operation of the supervisory control equipment, proper provision for the maintenance of this equipment warranted special consideration. Just after the starting of revenue service, a second man familiar with telephone type relays, was employed as a helper, since it was felt that one man should be available at all times in case of emergency.

The routine maintenance of the supervisory control equipment requires 50 per cent of the

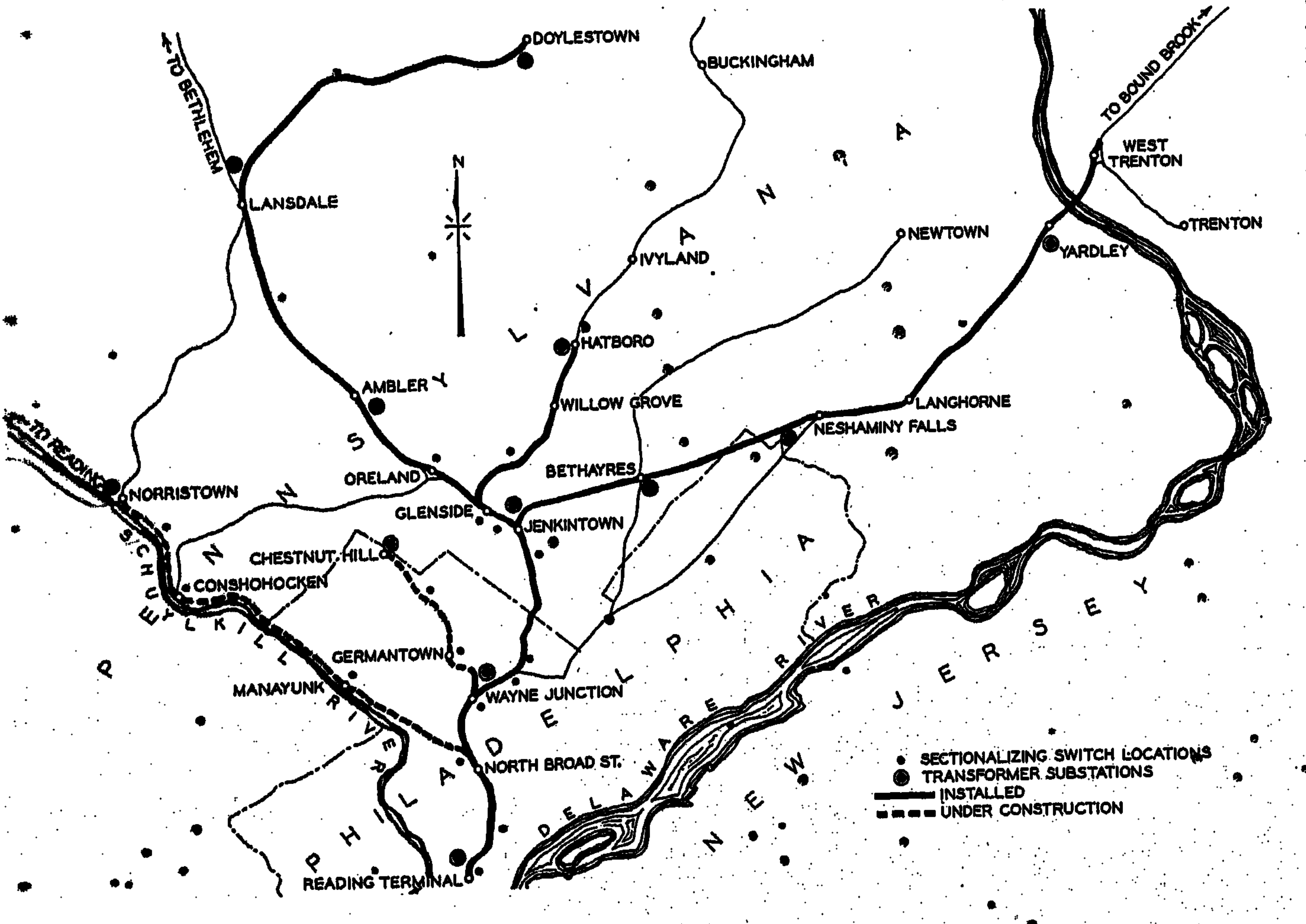

**Fig. 1.** The Reading-Philadelphia suburban electrification, to which supervisory control has been applied

time of 2 men, the remainder of their time being spent on general substation maintenance. The following supervisory inspection schedule is in effect:

1. Two-week Inspection:
    - Check of batteries
    - Check of charging equipment and charging rate
    - General inspection of relays
2. Three-month Inspection:
    - Detailed inspection of all equipment
    - Clean relay contacts
    - Adjust relay contacts
    - Check all moving parts
    - Calibrate voltage-indication relays

Once each week the power dispatcher operates every device including the opening and reclosing of each circuit breaker and motor-operated trolley sectionalizing-switch on the system. This procedure not only checks the supervisory control equipment but also checks the closing and tripping circuits together with the mechanisms of all devices. Close contact is maintained between the operating force and the engineering department. The power dispatcher's daily reports include supervisory control failures, together with their cause if known. In addition, a monthly report of supervisory control failures covering the details of each failure is compiled by the operating department. This report is analyzed, failures are classified, and a curve of monthly failures is plotted.

## RESULTS

The first 6 months of operation represents 126 station-months; 35,000 operations were performed and 35 failures occurred, or 1 failure per 1,000 operations. Of the 35 failures, 11 were due to interposing relays, 6 were caused by blown fuses, and 18 by failure of supervisory control twist keys and relays.

In many cases the constant visual indication given by the system diagram on the control board has provided the power dispatcher with the necessary information enabling him to think logically, clearly, and rapidly at the time of trouble. This resulted in the restoration of power in a minimum amount of time, thus reducing the time of train delays. The advantage of eliminating divided responsibility and possibility of error in communicating orders is borne out in the fact that not a single faulty switching operation has been performed. No operations not initiated by the power dispatcher were performed by the equipment.

Although its performance has been good, it must be recognized that supervisory control has not reached a final stage of perfection. The equipment can be improved by further eliminating the possibility of failures. Systems where line wires loop through stations are undesirable when several stations are operated over the same set of line wires, since a fault in one station renders all stations inoperative. With the present system in which stations are operated in parallel across line wires, certain troubles tie up the entire system. However, by disconnecting the faulty station the remainder of the system can be operated. It may be possible that a scheme for automatically disconnecting the faulty station can be developed. High speed, together with a minimum number of line wires, is desirable.

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# Oxid Coatings on Aluminum

**Although possessing great affinity for oxygen, aluminum has the unique property of being able to protect itself from corrosion by forming on its surface a hard, thin, and almost invisible oxid coating. Characteristics of this film and some of its many uses are described in this article.**

By

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INTEREST in oxid coatings on aluminum began with the discovery of the metal about 100 years ago, as the chemical attraction of aluminum for oxygen is one of the most important characteristics of the metal. At various times in the history of aluminum, attention has been focused upon the oxid film, from the scientific standpoint or from the commercial standpoint. To the scientist the electrical characteristics of the oxid film have been of great theoretical interest and for many years have been the subject of experimental study and speculation. Important commercial uses of the film in various electrical devices has followed the scientific studies.

Aluminum owes its stability and resistance to corrosion to the invisible oxid film always present. Whenever exposed to air containing moisture, the metal immediately becomes coated with a film of oxid; this film ordinarily is invisible and not more than a relatively few wavelengths of light in thickness. In general the film is quite impermeable, so that pure aluminum will stand exposure to water with little corrosive action. The presence of this oxid film is quite apparent when one attempts to amalgamate aluminum. Aluminum and mercury combine readily, but when covered by an oxid film the mercury will not wet the aluminum and hence will not combine with it. Even if the aluminum is freshly abraded, as by filing or scratching, and then plunged into mercury, no action takes place because the oxid film reforms instantly. If, however, the oxid film is removed by abrasion while immersed in the mercury and out of contact with air, amalgamation takes place.

A highly important characteristic of this oxid film is its impermeability. Oxid formed from

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Full text of a paper "Oxid Coatings on Aluminum" (No. 32-78) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932.

aluminum occupies a greater volume than the aluminum from which it is formed; apparently this results in a compact and non-porous film with great protective properties. Even on continued heating at high temperatures, the film shows relatively little increase in thickness. Although impermeable to gases, the oxid film as naturally formed has a negligible electrical insulating effect and offers little resistance to the passage of current, even at very low voltages. This is fortunate, and permits the manufacture, for example, of variable air condensers with aluminum plates held in their mountings by mechanical pressure, with no increase in resistance over similar condensers of other metals in which the plates are soldered to the supporting pillars.

The asymmetric character of the film "artificially" produced, when aluminum is made the anode in various electrolytes, has been of great scientific commercial interest. Since the rise of the radio industry, extensive use of film-coated aluminum has been made in the electrolytic rectifier and, more recently, in the electrolytic condenser. High capacity in small volume and at low cost has proved a great stimulus to the development of the electrolytic condenser. Originally marketed in the form of a cell containing electrodes immersed in a substantial volume of electrolyte, the trend for small condensers, at last, is now largely toward the so-called "dry" form, in which a limited volume of electrolyte is held absorbed in a paste kept in contact with the electrodes. In all of these devices, however, the oxid film—at least the active part—is quite thin.

## THICKER COATINGS NOW BEING USED

Extensive use of oxid coatings having thicknesses comparable with those of paint films is a relatively recent development. If aluminum is made the anode in boric acid, the potential drop at the anode may be increased to a value of about 400 to 600 volts with very little current passing; the film, once formed, is thin and shows little tendency to decrease or increase in thickness. If, however, an electrolyte of different chemical characteristics is chosen, as, for example, a dilute solution of sulphuric acid or oxalic acid, a different behavior is noted. Within limits, the oxid film may be built up to a substantial thickness, since the potential may not rise above from 10 to 50 volts, and current continues to pass until thick films have been formed, say, 0.001 in. or over. Films formed in this latter way, when removed from the electrolyte and dried, have desirable mechanical, chemical, and electrical properties. The film in respect to hardness partakes of the characteristics of corundum, which is a hard, crystalline oxid, $Al_2O_3$. Because of this hardness, it possesses wear and abrasion-resistant qualities that can be made use of commercially.

Dielectric strength of these dry films can be made sufficiently high so that the films can be used for electrical insulation on wire, sheet, and foil, to be used as conductors and in condensers, respectively. In a chemical way, the films can be made with or without high adsorptive properties, so that they can be colored by absorption of dyes or mineral pigments; this opens up a new and extensive field for obtaining decorative effects. These thick oxid films on aluminum can be obtained not only by electrolytic treatment, but also by direct chemical action of various solutions on aluminum. Properties of these thick films are discussed in succeeding paragraphs.

In the formation of oxid coatings on aluminum by electrolysis oxid is formed at the interface between the aluminum and any oxid coat already existing. It might be thought, therefore, that the oxid coat could be increased to any thickness as long as the coating remains sufficiently permeable to permit the passage of current. Another limiting factor, however, is the solvent action of the electrolyte upon the film. Most electrolytes that are useful for producing thick coatings have an appreciable solvent capacity for aluminum oxid, usually increasing with rise in temperature; thus the anodic coating process becomes a race between the oxidizing action of the current and the solvent action of the electrolyte. The oxid coating also may have its characteristics changed by specific chemical reactions with the electrolyte.

An interesting experiment with an electrolyte of low solvent action gave a series of 8 coatings which by direct measurement of microscopic sections were found to have an average thickness of 0.00038 in. Direct measurement showed also that the aluminum sheet used in the experiment had increased in thickness by 0.0002 in. as a result of oxidation on both sides, so that the increase in thickness attributable to a single oxid film is 0.0001 in. The aluminum, therefore, in forming the oxid increased in volume by about 35 per cent. This is a difficult measurement to make with precision, the values obtained ranging from about 15 to 60 per cent. When, however, electrolysis was carried out with a solution in which aluminum oxid was highly soluble, the sheet frequently showed a total decrease in thickness many times the thickness of the oxid coating, even though the coating itself was of substantial thickness.

Coatings described in the previous paragraph were subjected to X-ray examination by the powder method and were found to be amorphous—at least no evidence of crystallinity was observed. Water in the coating there probably is held by adsorption, and not as one of the crystalline hydrates of aluminum. However, by a special after-treatment the oxid can be converted, at least in part, into crystalline aluminum mono-hydrate; this change is accomplished by a marked decrease in the permeability of the film and an increase in its dielectric and protective properties.

## OXID FILM AN INSULATOR

From the standpoint of the electrical engineer, the possibility of using an oxid coat as insulation on aluminum conductors is a matter of considerable interest. The idea, of course, is quite old and has been applied commercially to some extent, particularly abroad. The present advanced technique and knowledge of oxid coatings now available has created a new interest in these coatings. In certain types of electrical machinery, the use of aluminum conductors would be advantageous from the standpoint of weight reduction. Another advantage of the oxid-coat insulation is that it is non-combustible and will withstand fairly high temperatures without deterioration. There is even a possibility of its use as a dielectric in dry condensers.

Breakdown voltage of oxid films is roughly proportional to the thickness of the film. The breakdown characteristics, however, are dependent also upon the specific physical and chemical characteristics of the film. In Fig. 1 is shown a series of observations on the breakdown voltage of oxid films on commercially pure aluminum, plotted as a function of the thickness of the oxid film. This particular film was made by anodic coating of aluminum in a 15 per cent solution of sulfuric acid at a temperature of 75 deg. fahr. To produce an oxid film 1 mil thick required a period of about 1 hr, under prevailing operating conditions. By special after-treatment, without introducing any organic material into the film such as that referred to in a previous paragraph, the breakdown voltage of the film may be increased as much as 50 per cent or more. The oxid coatings also can be produced in absorbent form, and in this condition can be impregnated with oils, waxes, or enamels; such treatment imparts to the coatings a substantial increase in insulating value.

### OXID COATING HARDER THAN BASE METAL

That the oxid coat is much harder than the base metal is at once obvious if an attempt is made to scratch the surface. Some quantitative data have been obtained by subjecting films of various thicknesses to an abrasion test consisting of abrading the surface with an aloxite wheel under light pressure. The abrasion resistance is measured in terms of the number of revolutions which the specimen makes against the abrasive wheel. These data are given in the Table I.

According to Table I, the abrasion resistance of an oxid coating increases rapidly as the thickness of the film increases beyond about 0.3 to 0.4 mil. For comparison with these figures, reference may be made to the abrasion resistance of enamel and varnish coats such as applied in finishing metal furniture and office equipment. A typical finish of this type, consisting of primer, 2 ground coats, graining coat, and 3 coats of finishing varnish, having a total thickness of 3 mils, showed an abrasion resistance of 306 revolutions; a somewhat different finish of the same thickness showed an abrasion resistance of 1,095 revolutions. For equivalent thicknesses, therefore, the oxid coat is substantially harder than the baked enamel just mentioned.

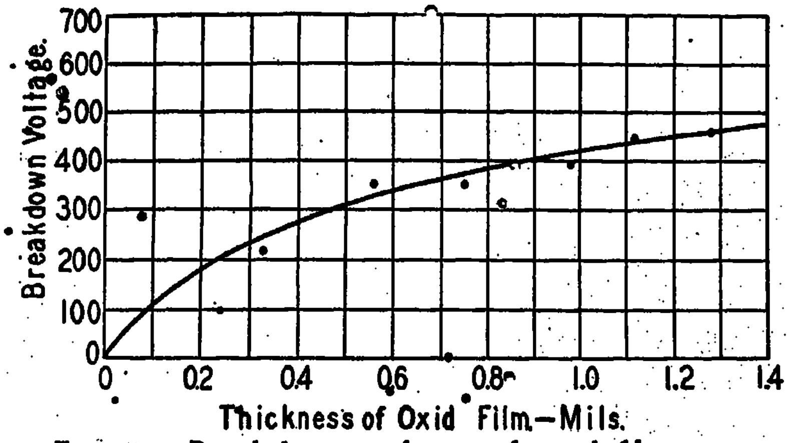

**Fig. 1. Breakdown voltage of oxid films on commercially pure aluminum**

**Table I—Abrasion Resistance of Aluminum Oxid Coatings**

| Thickness of Coating, Inches | Abrasion Resistance, Revolutions Against Aloxite Wheel |
|---|---|
| 0.00011 | 15 |
| 0.00019 | 95 |
| 0.00031 | 268 |
| 0.00037 | 365 |
| 0.00074 | 2,563 |
| 0.00148 | 7,061 |

Oxid films not over 0.1 to 0.3 mil thick on thin sheet can be formed readily into bottle caps and similar articles. These films of course crack on bending, but the cracks are so minute as to be generally undetectable except under the microscope; adhesion of the film to the metal is so firm that no flaking occurs even when these cracks are present. These minute cracks appear to have very little, if any, effect on the insulating value of the coating. In addition, tests made so far indicate that the oxid coat does not affect unfavorably the fatigue strength of the base metal.

As has been mentioned already, oxid coatings may be applied to aluminum by chemical dip methods without the use of electric current. Such coatings, while unusually relatively thin, nevertheless have been used commercially, both in the United States and abroad, for their insulating value. Because of their characteristics, such coatings are of use only when subjected to low voltages; therefore their greatest use is in motor field coils and similar applications where the voltage drop between the conductors is low.

Certain types of oxid coatings are decidedly absorbent and can be colored readily with dyes and mineral pigments. These methods of coloring the oxid coatings present interesting possibilities in the electrical industry. Wires may be colored, for example, to indicate polarity of direct current; where several wires are in a single conduit, the colors may be used to identify the various circuits. For rapid heat dissipation, busbars and other conductors may be colored black. The bottoms of aluminum utensils for use on electric stoves may be colored black for better heat absorption. Commercialization of plain and colored "alumilite" finishes in the electrical industry already is under way; oxid-coated and colored nameplates are finding increasing use; a tremendous number of aluminum flashlight cases in attractive colors has been manufactured. Furthermore, practically the entire electric refrigerator industry has turned to the use of aluminum refrigerator trays and grids with plain anodic coating. It is quite evident that these finishes will be of increasing value to the electrical industry in the future.

# A Bridge Method of Testing Welds

**A new non-destructive method of testing welds by an electrical means has been developed which can be applied to welds made in the field as well as to those made in the shop. A reliability of 8 out of 9 welds tested, or 89 per cent, already has been obtained and gives good promise for the future. The method may be applied also to the finding of flaws in other homogeneous objects of magnetic materials.**

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SINCE the advent of welding there has been an ever-growing demand for a simple and satisfactory non-destructive test for completed welds. Several schemes have been devised and used successfully in the experimental laboratory and in the shop. Among these are (1) the stethoscope method, (2) the X-ray method, and (3) various electrical and magnetic methods.

Of these systems the X-ray method and one of the electrical methods have been successfully used in the routine production testing of welded boilers at the Babcock and Wilcox boiler works. Both of these systems, however, are chiefly limited to shop use, and are not readily adapted to the conditions of field work.

It has been suggested that a satisfactory non-destructive testing device should possess the following 3 characteristics: first, the device must be portable; second, it must give instrumental indication of flaws; and third, it must give instrumental indication of the relative strength of the weld as compared with the stock from which it was made. Thus the ultimate goal to be achieved was set, and constantly kept in mind as the work progressed. After due consideration, it was believed that an a-c bridge with a visual balance indicator offered the greatest possibilities.

## THEORY OF THE TEST

It is well known that the inductance and the effective resistance of a coil which has an iron core depend upon the magnetic circuit. Therefore if an air-gap is introduced into that magnetic circuit, then the inductance and effective resistance have new values. This is the basis upon which the bridge method of testing welds operates.

The most satisfactory method of measuring the inductance and effective resistance of a coil is by some form of impedance bridge. In the preliminary tests, an exploring device similar to that shown in Fig. 1 was constructed and connected to an impedance bridge which was available. This particular bridge did not give good results. Investigation of the theory of its operation showed that for measuring inductance it was a comparison bridge and the least accurate of the general types of the impedance bridge. In the comparison bridge the calibrated standard is the same as the unknown; that is, a standard inductance is used for measuring an unknown inductance and a standard condenser for measuring an unknown condenser. This type of bridge is difficult to balance with very great accuracy. The resonance bridge gives a much more sharply defined balance point and is therefore much more accurate. It makes use of a standard condenser to measure an unknown inductance and a standard inductance to measure an unknown condenser. A series resonance bridge therefore was constructed for making the measurements of the change in the inductance and the effective resistance of the exploring device.

## DESCRIPTION OF APPARATUS

The complete equipment which finally was developed is shown in Fig. 3, the schematic diagram being shown in Fig. 4. The equipment consists of 4 major parts:

1. The oscillator which supplies the alternating current for the operation of the bridge.
2. The bridge by which the measurements are made.
3. The exploring device for examining the weld.
4. The balance indicator which shows the condition of the weld.

The oscillator consists of a single tube with inductive coupling between the plate and grid, and with a transformer in the plate circuit for obtaining the output. The variable condenser shown connected across the grid coil controls the frequency. The low pass filter section was used to eliminate the harmonics from the oscillator output.

In the impedance bridge $R_1$ and $R_2$ are the ratio arms of exactly equal non-inductive resistors. The variable resistance $R_3$ balances the effective resistance

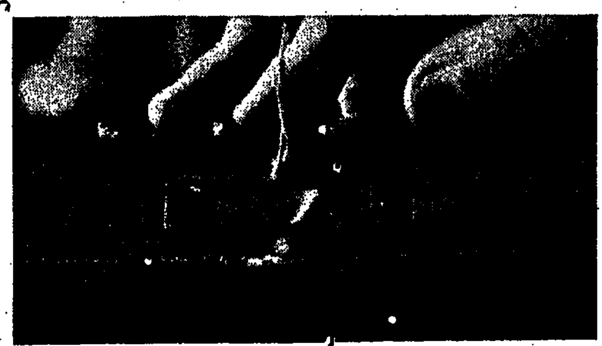

Fig. 1. (Left) Exploring device across a weld

Fig. 2. (Right) Balance indicator used in laboratory

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Essentially full text of "A Bridge Method of Testing Welds," presented before an A.I.E.E. joint meeting of the Portland Section and Oregon State College Student Branch, at Corvallis, Ore., May 23, 1931. This paper, written while the author was a senior in electrical engineering at Oregon State College, was awarded the Institute's 1931 national prize for Branch paper.

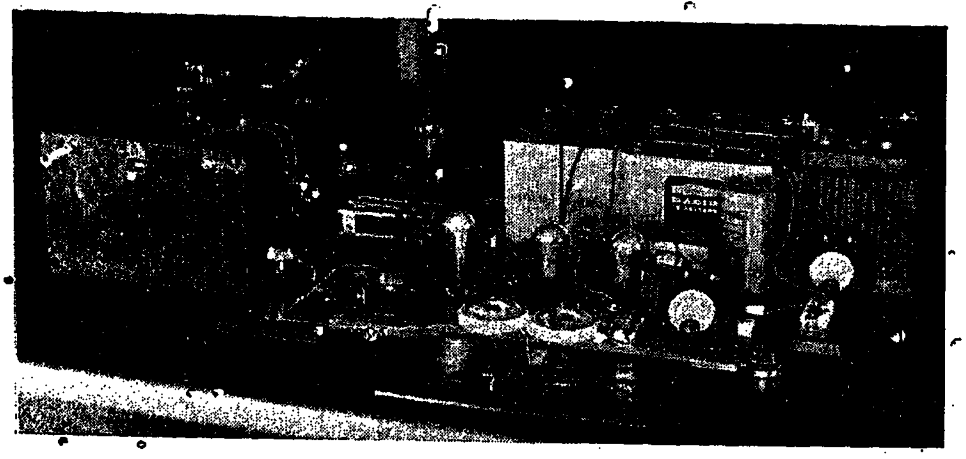


Fig. 3. Complete laboratory equipment used in test

of the exploring device. The condenser *C* balances out the inductance of the exploring device. It consists of several fixed condensers in parallel with the standard variable air condenser.

The exploring device consists of 2 coils each of many turns of fine wire wound on the 2 legs of a *U*-shaped magnetic circuit, the magnetic circuit being closed by the weld under test as shown in Fig. 1.

The balance indicator is the most complicated of the 4 parts which make up the equipment. It is a very sensitive vacuum-tube voltmeter. This high sensitivity is obtained by means of the amplifier which is composed of the 3 transformers and the first 2 tubes shown in Fig. 3. The first of these is a *UX*240 with an amplification factor of 30; and the second, a *UX*201-*A* with an amplification factor of 8. This amplifier has a voltage gain of approximately 20,000 to 1. The detector tube is a *UX*201-*A* with the milliammeter shown in Fig. 2 in the plate circuit and shunted by a large condenser, and the plate battery to bypass any unrectified alternating current. The milliammeter was provided with a shunt *S* to increase its range to 10 times full scale value during the preliminary balancing and when first energizing the tube filaments. Also a high variable resistance in series with a single dry cell was connected as shown in Fig. 4 so that it sent a current through the milliammeter in the reverse direction to that of the tube. By this means it was possible to make the voltmeter read zero when there was no voltage impressed across its terminals, and the steady plate current reading could be removed from the instrument.

A vacuum-tube voltmeter was used for 2 reasons: first, it required almost no power from the bridge for its operation as would a thermocouple or ordinary voltmeter; and second, it was much more sensitive and had a uniform scale. The minimum sensitivity was $1^1/_4$ mv. Each succeeding millivolt up to about 4, which was as high as the calibration was carried, caused an increase in the deflection of about 0.10 ma. At these low values the calibration curve was not always a straight line but followed the tube characteristic.

## METHOD OF MAKING THE TESTS

Rated current was maintained in the tube filaments at all times by the aid of the filament ammeter shown in front of the right hand storage battery in Fig. 3. The oscillator filament ammeter does not show plainly but was very important in keeping the output at a constant level. The reverse current then was adjusted so that with the voltmeter terminals open and the shunt removed the milliammeter had a reading of 0.10 which hereafter will be used arbitrarily as 1.0, thus increasing each reading to a whole number for each 0.1 ma of current.

The shunt switch then was closed again to protect the milliammeter, and the output of the bridge was connected to the voltmeter by closing the switch shown just behind the first tube in Fig. 3. Then the exploring device was placed on the stock near the weld, but not across it, and the bridge brought into balance by adjusting the variable air condenser and the variable resistor shown beside it. A balance was shown by a minimum reading of the voltmeter. When the reading was as near zero as possible the shunt was removed by opening the switch (the handle of which shows from behind the milliammeter) thus greatly increasing the sensitivity. The final balance then was obtained and the reading arbitrarily made exactly 1.0 by means of the reverse current control resistor which is shown beside the milliammeter in Fig. 3.

The exploring device then was slid along the plate to see that the balance was correct and that there was no very marked change in the indicator reading. The shunting switch was then closed and the exploring device placed over the weld as in Fig. 1. If the deflection indicated that the reading would not be off scale the shunting switch was opened and the exploring device moved along the weld, while the operator observed the indicator reading.

If the weld was as good as the stock from which it was made, then the bridge balance would be undisturbed and the reading was the same as it had been over the stock, or 1.0; but if there was a blow hole or burned place in the weld this would unbalance the bridge by changing the inductance and effective resistance of the exploring device. This flaw was indicated by an increase in the reading to 2.1 or some other value as the exploring device passed over the flaw. Also a note was made of the percentage of the width of the weld for which this high reading existed; this together with the lowest reading over the weld formed the basis for computing the efficiency of the weld. To take an actual example; the reading with the exploring device over the stock was 1.0, the minimum reading over the weld was 1.7, and the maximum reading was 2.0 for 60 per cent of the

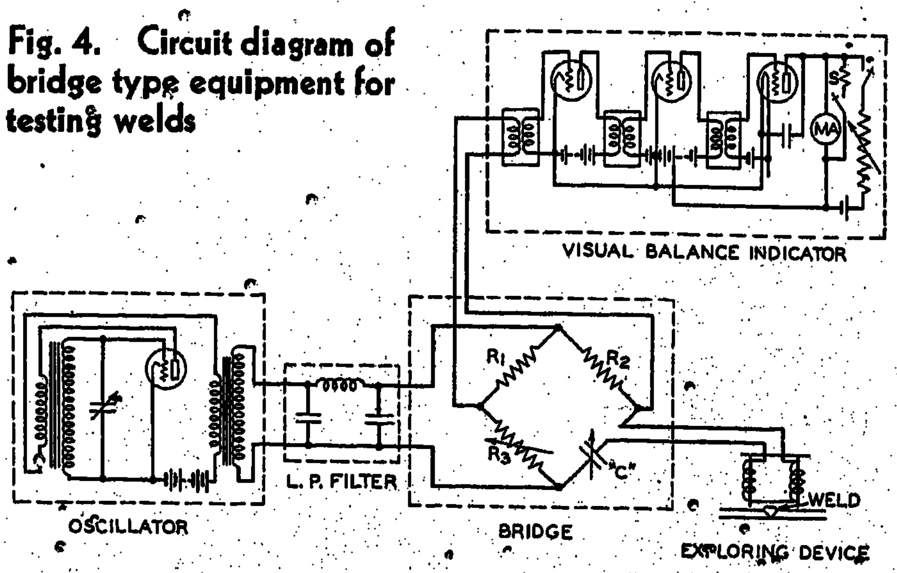


Fig. 4. Circuit diagram of bridge type equipment for testing welds

width of the weld. The efficiency was computed as the reading over the stock divided by the reading over the weld, or for the maximum efficiency 1.0 divided by 1.7 or 59 per cent, and for the minimum efficiency 1.0 divided by 2.0 or 50 per cent. But this lower efficiency was present for 60 per cent of the weld; therefore the true efficiency was 60 per cent of the way from 59 per cent toward 50 per cent, or 54 per cent for the weighted efficiency of the weld.

Before making the tests the loose scale and the splatter were removed by rubbing lightly with a piece of emery cloth. This was done because these small globules prevented smoothly sliding the exploring device along and gave false indications when they touched the pole pieces.

### Results Obtained

Through the months of January and February, 1931, about 18 welds made by students were available each week for testing. These were tested by the bridge method and their efficiencies calculated as explained. These welds then were tested in tension to obtain an actual breaking load for each one. During nearly every week some one of the specimens failed in the stock instead of in the weld, and the load at which that failure occurred was used as the strength of the stock for that week in computing the actual efficiencies. These actual efficiencies were computed by dividing the load at which the weld failed by the load at which the stock failed, because all of the welds were made from $^1/_4$ x 2 in. stock and except for slight irregularities in the stock due to rolling, had the same area.

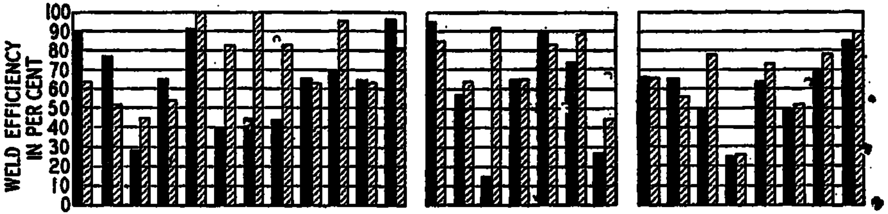
The results of tests upon an early group of specimens from which the scale was not removed are shown in Fig. 5. At that time there were no copper legs on the exploring device, heavy paper being laid on the stock to give a smooth surface. In the next series of tests, the results of which are shown in Fig. 6, the scale and globules were removed from the welds with emery cloth, but paper was still used on which to slide the exploring device.

After the exploring device was equipped with copper legs as shown in Fig. 1, another group of welds was tested and retested until results could be duplicated readily to within 1 or 2 per cent. These welds were then tested in tension; the results are shown in Fig. 7.

### Discussion of Results

Even the first group of welds tested showed a tendency for the efficiency calculated from the bridge readings to follow the efficiencies found in the actual destructive tests. After the bridge testing technique was improved the results increased in reliability. For the group of Fig. 5 the reliability was 33 per cent; for the group of Fig. 6 it increased to 57 per cent; and for the group tested after the copper legs had been added and the paper eliminated, Fig. 7 shows that the reliability jumped to 89 per cent, which is most gratifying. This shows rather conclusively that the basic theory is sound and that the errors which occurred were due to imperfect apparatus and not to theory; for as the quality of the apparatus increased, so did the reliability of the tests.

In every change in the apparatus the 3 desirable characteristics were kept in mind and are fully met by the method. As to the first, portability, while the laboratory outfit used for the present series of tests is not exactly portable, nevertheless, there is no reason why both the space required and the weight cannot be very greatly reduced. The matter of small size can be accomplished readily by the proper choice of equipment. All of the parts except the batteries and the exploring device could be assembled in a box about one-half the size of the standard condenser shown at the left in Fig. 3. The matter of battery weight also can be controlled by using the very small sized light-weight batteries. The bridge method meets the second requirement; namely, that the indications be visual. It also meets the third requirement that the readings show a direct comparison with the stock.



**Figs. 5, 6, and 7. Results of early tests (left) before scale was removed from specimen; results obtained (middle) after removing scale; and later tests (right) after copper legs were used on exploring device and without paper laid on stock**

Efficiencies as obtained by the bridge method are shown as solid bars, and actual efficiencies from tension tests as the shaded bars

The exploring device shown in Fig. 1 was developed for testing single *V* butt welds, but can be modified for use in testing other kinds of welds. One design for reaching into corners is to bend the crossarm connecting the 2 pole pieces until the pole pieces form a right angle and one of them rides on each side of the angle. Another is to still keep the *U*-shape but to make the ends of the pole piece hemispherical in shape, so that when they are placed in the angle they still make as good contact as they did on the flat plate. An offset in the connecting crossarm which would allow one pole piece to operate at a lower level than the other would make it possible to test fillet welds when one piece of stock was placed on top of the other to form a lap weld.

Also it may be desirable to replace the long copper skid with 2 wheels and the short one with 1 wheel, all of non-magnetic material. It would still be necessary to remove the splatter since if rough spots come in contact with the pole piece the balance is disturbed.

The results obtained by this method are most promising; the reliability was increased with each improvement until with a slightly more stable oscillator and a suitable period for the tubes to become stable the results should be very satisfactory. This method does not involve the use of large currents and can be made self-contained and independent of outside power supply.

# Carrier Application to a Telegraph Plant

**Carrier communication has been found to provide an economical means of conveying not only telephonic but also telegraphic information. This article describes the transmission and equipment features of a 10-channel system recently developed for 4-wire operation in a strictly telegraph plant, and includes performance characteristics showing capabilities of the system.**

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USE OF CARRIER SYSTEMS has been rapidly increasing for the last 10 or more years in the wire communication networks of this and foreign countries. To a large extent, this is due to the economies realized from the use of this means of conveying telegraphic or telephonic information, especially over relatively long distances. A gradual increase in copper costs over the early part of this period no doubt was directly responsible for the increased application of carrier systems in the communication field. However, it is noteworthy that even at present low copper costs the use of carrier still maintains a liberal margin of economy. This is due mainly to the material advancement in the carrier art which has been manifest in circuit refinements, improved performance, and simplification of equipment design, as well as improvement in the technique of coordination with the same or other types of communication facilities.

The majority of applications has been confined, primarily, to telephone plants or communication networks, employing largely metallic circuits. This is natural to expect since the design and construction of the wire and cable plant for telephone operation possess the essential transmission requirements for satisfactory carrier operation. A quite different and, in many respects, more difficult problem is encountered in introducing carrier into a strictly telegraph plant because in general the growth of present-day telegraph plants has been restricted by the wide use of d-c telegraph circuits that could be operated fairly successfully on a ground return basis. Consequently, it has not been the general practise of the telegraph companies to construct and maintain their open wire and cable circuits in a way that would provide balanced metallic circuits suitable for carrier operation. Furthermore, the operating energy levels of the various circuits on the same lead are not restricted by the presence of other types of communication circuits occupying a frequency transmission range other than that required for d-c telegraph signals. In general, this outlines the fundamental difference in the transmission problem involved in applying carrier to a telegraph plant.

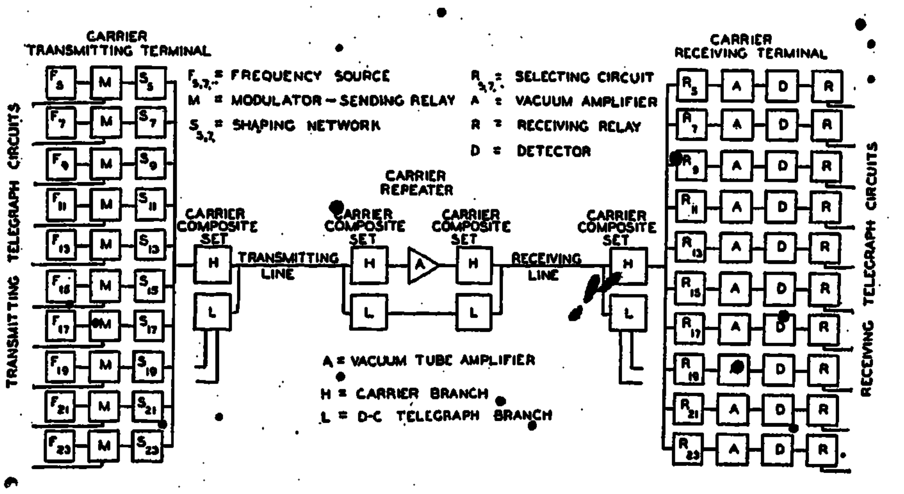
CARRIER TRANSMITTING TERMINAL
CARRIER RECEIVING TERMINAL
TRANSMITTING TELEGRAPH CIRCUITS
RECEIVING TELEGRAPH CIRCUITS
F5 F7 F9 F11 F13 F15 F17 F19 F21 F23
M
S5 S7 S9 S11 S13 S15 S17 S19 S21 S23
F5,7,.. = FREQUENCY SOURCE
M = MODULATOR – SENDING RELAY
S5,7, = SHAPING NETWORK
R5,7,.. = SELECTING CIRCUIT
A = VACUUM AMPLIFIER
R = RECEIVING RELAY
D = DETECTOR
CARRIER REPEATER
CARRIER COMPOSITE SET
TRANSMITTING LINE
RECEIVING LINE
H
L
A
A = VACUUM TUBE AMPLIFIER
H = CARRIER BRANCH
L = D-C TELEGRAPH BRANCH
R5 R7 R9 R11 R13 R15 R17 R19 R21 R23
D

**Fig. 1. Schematic diagram of 10-channel carrier telegraph system for 4-wire operation**

Frequency indicated in hundreds of cycles per second

Other equally important factors also enter into the problem, the foremost of which is the fundamental difference in the traffic requirements imposed on the telegraph plant by the particular class of communication business handled. Telegraph service by its very nature demands great flexibility; but even greater flexibility is needed when carrier is applied. Hence it has been found desirable to provide considerable flexibility in the design of the carrier equipment itself.

## GENERAL SYSTEM REQUIREMENTS

Technical development features arising from the specific problem of designing and developing a carrier telegraph system primarily for use in the extensive domestic telegraph plant of the Postal Telegraph-Cable Company are presented in this article. This includes the performance results obtained, and a detailed description of the final standardized system.

At the time this development was undertaken, a careful study first was made of all known types of carrier telegraph systems and accepted practises employed in both the United States and in foreign countries. From this study, together with a full appreciation of the problems peculiar to adapting carrier to a telegraph plant, it was possible to set up basic requirements to be met by a carrier system capable of delivering a satisfactory quality of signal and standard of service. As a result of this investigation, the following general requirements arbitrarily were set up as an ideal to be approached:

1. Each channel of the system should be capable of handling a quality of signal commercially suitable for existing or contemplated printer operation.

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Based upon "Carrier Application to a Telegraph Plant" presented at the A.I.E.E. winter convention, New York, N. Y., January 25–29, 1932. *Pamphlet copies not available.*

* Formerly of the International Communications Laboratories, New York, N. Y.

2. Transmission characteristics for all channels in any one particular system should be uniform, to permit unlimited interchangeability of telegraph printer facilities.

3. Transmission stability of the system should not impose any additional limitations on the operating requirements for any particular telegraph facilities used over the carrier system.

4. A unit equipment design should be employed which would embody sufficient flexibility to fulfil economically the demands of a diversified traffic growth.

5. The system should coordinate to the fullest extent with the inside and outside plants for present or future telegraph facilities of the same or different type.

Naturally, additional requirements of a more specific nature were prescribed for the initial design. These have been omitted since they do not materially relate to the subject matter of this article.

## Technical Features of Design

Having chosen suitable relays with satisfactory operating characteristics, particularly with regard to efficiency, sensitivity, and freedom from chatter and bounce, the first consideration was that of frequency band width and frequency allocation of the carriers. While the required signaling band width was well defined for the existing printer facilities, it was logical to make provision for band widths expected from contemplated future telegraph facilities under development. This led to a design of selecting circuit which could be adjusted readily to any desired band width. Details of these structures will be treated more at length later.

In reviewing all previously published information at hand, it was apparent that some variance among authorities existed in regard to the proper relation that should be sustained between signaling speed and minimum band width necessary to satisfy fundamental transmission requirements. A proportionality factor of 1.5 times twice the fundamental signaling frequency was used in determining the appropriate band width. This is in substantial agreement with prevailing practises, which specify equivalent values ranging from 1.2 to 2.0 times twice the dot frequency. Other practical considerations resulted in prescribing frequency bands wider than the theoretical value indicated, in order to provide operating margins that would insure continuity of service.

Directly related to the matter of band width is the problem of allocating the carrier frequencies. Obviously, the degree of selectivity which could be obtained economically was the essential limitation in fixing the positions of the carrier frequencies in the assigned frequency spectrum. As this system was to be the initial carrier system in an existing telegraph plant made up almost exclusively of d-c telegraph facilities occupying the lowest end of the frequency spectrum, it was natural to assign for this carrier system a frequency range immediately above, in the voice range.

It is well recognized of course that practical considerations dictate how efficiently the frequency range should be utilized. For example, the frequency space may be divided for suitable operation of start-stop printers. This would require a band width of approximately 75 cycles and would permit relatively close spacing of the carrier frequencies. For a given frequency range a given number of channels could be allocated, each of which would have an operating limit of 65 words per minute. By slightly increasing the band width to 100 cycles, it would be possible to divide this same given frequency range into a fewer number of channels, each capable of transmitting 2 channel multiplex signals with an operating capacity of 120 words per min. per carrier channel. This line of reasoning may be continued on to include 3- or 4-channel multiplex operation. While it would be possible to determine from such an analysis the best combination, from a standpoint of obtaining the greatest message capacity, in a given frequency range, it would not necessarily make the most practical use of the frequency space. The band widths finally chosen were based upon these considerations and also upon the smoothness with which carrier telegraph systems could be introduced into the telegraph plant. It appeared advisable to restrict the lowest carrier frequency to 500 cycles in order to allow ample frequency space for retaining on the same wires existing high speed d-c telegraph circuits.

Fundamental operation of all carrier telegraph systems is essentially the same. Before describing this system in detail it will be well to enumerate the principal components that go to make up any carrier telegraph system. A system comprises several individual channels, uniformly alike in make-up and normally comprised of the following essential parts:

1. A transmitting terminal consisting of frequency sources, modulators, and shaping networks.

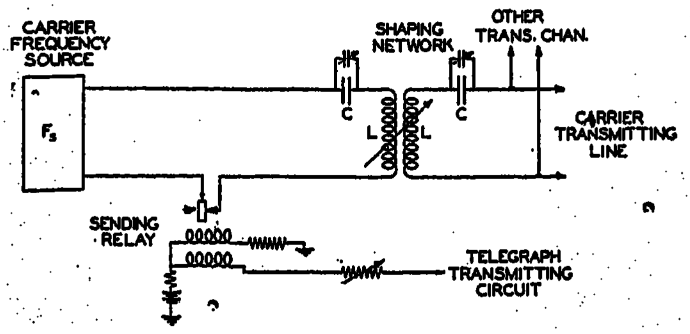

Fig. 2. Schematic diagram of transmitting channel

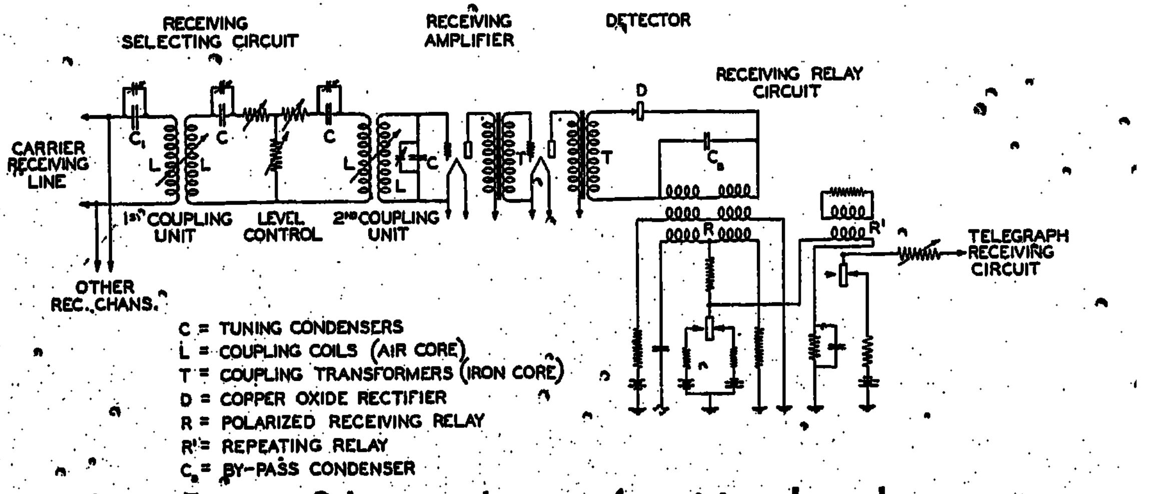

Fig. 3. Schematic diagram of receiving channel

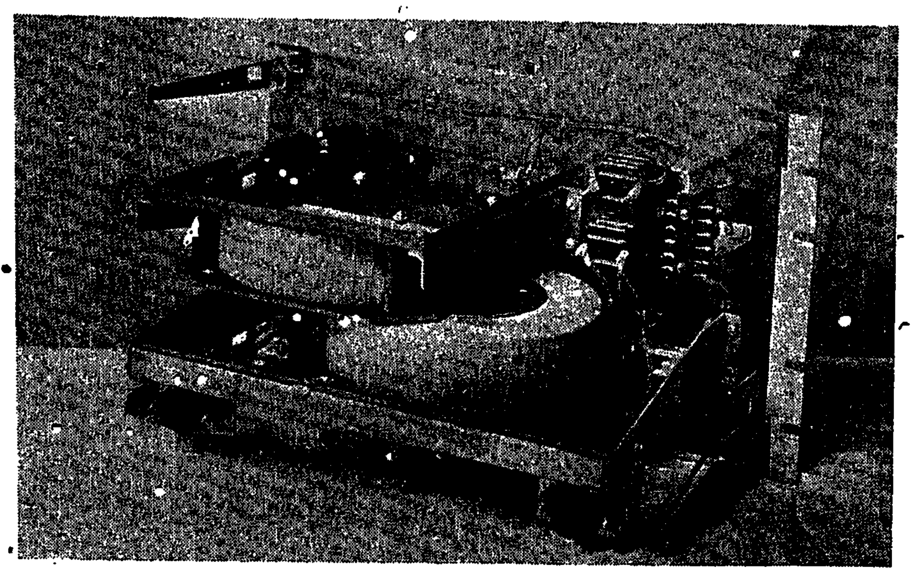

Fig. 4. Assembly of shaping network unit

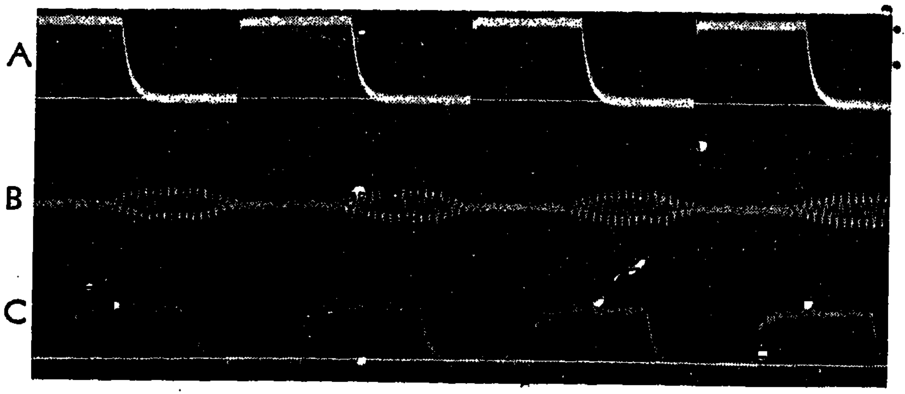

Fig. 5. Oscillogram showing over-all telegraph transmission over a typical channel

A—Signal repeated by receiving relay to receiving equipment
B—Modulated carrier current shaped for transmission
C—Originating telegraph signal received from transmitting telegraph equipment

2. Repeaters consisting of 2 separate one-way amplifiers each common to all of the channels.

3. A receiving terminal consisting of selecting circuits, amplifiers, detectors, and receiving relays.

Each tuning fork generator operates on 100 to 200 milliamperes of current from a 6-volt battery supply in common with all other generators. From each generator 60 milliwatts of power into a 600-ohm load circuit is available, if transmitting level conditions require utilizing the maximum generator outputs. Generated power output available from the multi-frequency generator at each channel frequency is 375 milliwatts into a 600-ohm load circuit. Speed control equipment associated with the unit insures a constancy of generated frequencies to within 1/4 of a per cent, for normal line voltage variations.

The purpose and functions of each of these parts already have been ably described in previous publications; therefore, the remainder of this article will be confined to a more detailed description of the apparatus developed for this particular system.

The system as a whole has been designed initially for 4-wire operation over composited open wire telegraph lines. Fig. 1 shows schematically the system layout of half of the equipment for 10 2-way carrier channels; the other half of the system obviously is identical to that part shown except that it transmits in the opposite direction.

One of the unique features incorporated in the system design was the degree of flexibility provided for satisfying the diversified use of carrier telegraph circuits, and which proved essential for meeting economically the requirements of a domestic telegraph plant. Application to existing trunk routes between important telegraph centers over which the traffic demands are heavy invariably will call for initial installations of complete 10-channel systems. At the same time, for secondary leads between less important centers, normal traffic growth may be provided for more economically by systems composed of fewer channels, due to the unit method of design. Systems consisting of from 1 to 6 channels may be equipped with individual channel frequency sources, namely, double carbon button tuning fork generators supplying carrier frequencies of 500, 700, 900, 1,100, 1,300, and 1,500 cycles per sec.; for systems requiring more than 6 channels a carrier frequency source from a multi-frequency generator supplying the following frequencies is provided: 500, 700, 900, 1,100, 1,300, 1,500, 1,700, 1,900, 2,100, and 2,300 cycles per sec.

It is readily apparent that a system design such as this is capable of being adapted to the usual communication network in an economical manner. The providing of additional channels for operating systems of 1, 2, 3, or more channels may be carried out expeditiously, without affecting the channels already in service. When a system has grown to 6 channels and additional channels are required, the individual tuning fork generators are replaced by a multi-frequency generator.

Superposition of the carrier system upon the telegraph lines is accomplished by compositing. Carrier composite sets are provided at the terminals and repeater points for restricting the carrier and d-c telegraph frequencies to their respective paths. The low frequency portion of the composite set requires a rather exacting design, as the d-c telegraph facilities operate at high speeds over the circuits employing ground return.

Telegraph line wires, which normally are untransposed for d-c operation, must be transposed to provide a suitable metallic circuit relatively free from noise or external interference for a carrier telegraph system. Loading of conductors in entrance and intermediate cables is required also, if full advantage of efficient transmission is to be realized.

## TRANSMITTING TERMINAL

In describing the transmitting and receiving channels, a description of an individual channel will suffice since all of the important units that make up the complete system are identical except for initial adjustment. A schematic diagram of a transmitting channel is shown in Fig. 2.

As previously mentioned, the carrier frequency source may be derived from either 1 or 2 different units, depending upon the number of channels making up any particular installation. Impressing the signals upon these carrier frequencies is commonly known as modulation. In carrier telegraph operation, this process may be carried out by interrupting a steady carrier frequency source in accordance with the actual signaling frequencies of the originating telegraph signals. However, in the circuit arrangements of this system, superimposing telegraph signals on the carrier by open-circuiting between the carrier generator and the shaping network, what might be termed series modulation, has proved the most satisfactory. The method is evident from the circuit shown in Fig. 2.

It has been shown very clearly by mathematical analysis, and substantiated in practise, that a relatively small portion of the side frequencies present in the telegraph signal need be transmitted over a carrier circuit. (See "Certain Factors Affecting Telegraph Speed," H. Nyquist, A.I.E.E. Jl. v. 43, p. 124; "Voice Frequency Telegraphs," W. Cruickshank, *Journal* of the I.E.E., July 1929, v. 67, No. 391, p. 813; and "The Building-Up Processes in Wave Filters," K. Kupfmuller, *Elec. Na. Tech.*, 1924, v. 1, p. 112.) The degree to which the side frequencies may be limited is dependent entirely upon the signaling speed and the signal quality that will insure satisfactory performance of the particular type of telegraph equipment used in conjunction with the carrier system.

One of the outstanding features worthy of note in the design of this system is the application of the simplest known type of selecting circuit. The familiar coupled-tuned circuit upon which the early wireless art depended for discrimination will be recognized in the shaping networks and receiving selecting circuits which form the essential parts of this carrier system development. The unique solution of the coupled tuned circuit problem by one of the authors, L. A. Kelley, has made possible a simple and convenient method for designing selecting circuits to meet any requirements for which they may be adapted. A detailed explanation of the method is presented in the article immediately following this one.

Treatment of coupled tuned circuits by this method offers a distinct advantage over existing technique for handling selecting circuit design, inasmuch as it is possible to determine the operating characteristics which a given selecting circuit will possess when connected into the working circuit. The importance of equipping carrier systems with selecting circuits uniform in structure and performance cannot be overemphasized. At the same time, if full economic advantage is to be realized from carrier operation, it is equally important that the manufacturing costs to produce the selecting equipment should be consistent with those for the other related equipment.

As may be noted under the discussion regarding performance, it has been possible to develop for this system relatively inexpensive shaping networks and receiving selecting circuits (patent applied for) that meet especially well all transmission requirements imposed. This is accomplished primarily by designing the selecting units for the entire system so that only one type of inductance coil is used throughout; obviously this greatly simplifies the manufacturing problem for selecting circuit equipment from the standpoint of electrical and mechanical dimensions. Advantage is taken of the desirable properties of the air core inductance coil for eliminating the possibility of modulation effects from the selecting circuits. A double tuned circuit is embodied in the shaping networks used at the transmitting terminals. Mounting arrangements for the circuit elements have been worked out in a convenient assembly, as shown in Fig. 4. As may be noted one inductance element is movable with respect to the other fixed inductance element; a calibrated scale is provided in order that any desired degree of coupling may be easily obtained. The major portion of each capacitive element is composed of fixed units, with the remainder made up of small adjustable units permitting closer tuning adjustment after the entire unit has been assembled.

## RECEIVING TERMINAL

Adequate selectivity for separating out the various modulated carrier frequencies at the receiving terminal is obtained from triple tuned circuits embodying the same principles of design and equipment assembly as the transmitting shaping networks. A level-control network is inserted between the 2 halves of the selecting unit, as a convenient means of adjusting the individual channel frequencies to the proper operating level without appreciably affecting the transmission characteristic of the selecting units. A 10-db range for transmission level adjustments is provided in a continuously variable section of the level-control unit. This permits close regulation for optimum operating conditions. Fixed pads may be added to this 10-db unit, if desired. The last tuning condenser of the second section of the selecting circuit is connected in parallel with the input to the receiving channel amplifier, as an efficient means of coupling. Fig. 3 shows in schematic form the entire receiving circuit.

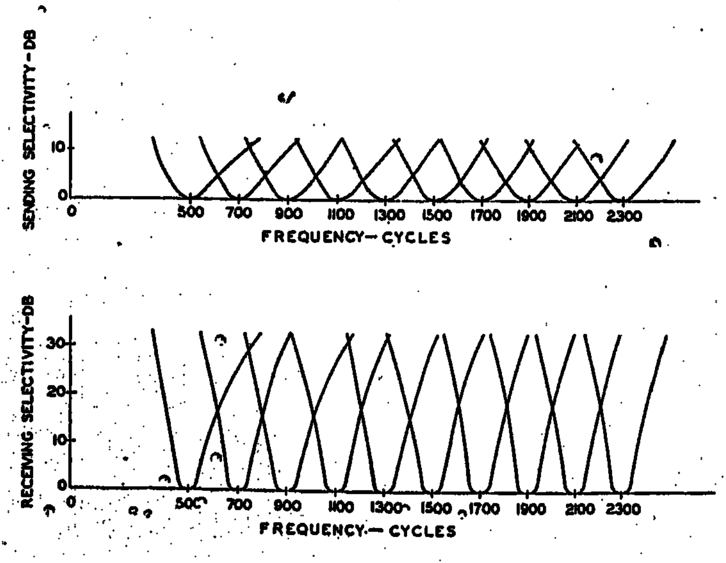

Fig. 6. (Left) Representative transmission characteristics of shaping net-works and receiving selecting circuits

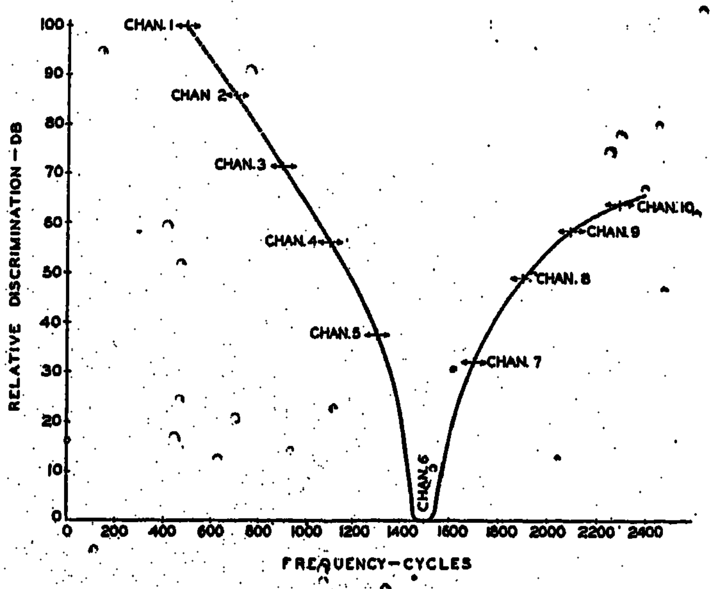

Fig. 7. (Right) Discrimination of a typical receiving selecting circuit

A vacuum tube amplifier having 2 stages of transformer coupled amplification is provided for each individual receiving channel. A maximum over-all receiving circuit sensitivity equivalent to 2.0 milliamperes down 26 to 30 db may be obtained for any of the channels. Vacuum tubes developed for these amplifiers as well as for the repeater amplifiers, have a voltage amplification factor of approximately 6 and an output impedance of 4,000 to 6,000 ohms. They require 0.45 amp filament current at 5 volts and are operated at a plate potential of 150 volts.

Conversion of the received a-c signals to d-c impulses is accomplished by means of a dry copper oxid rectifier. This rectifier is used in series arrangement between the output of the receiving amplifier and the receiving relay. Adapting this type of rectifier to conform to the requirements imposed on the receiving circuit has furnished a stable detector circuit not influenced by power supply variations. Maintenance and operating requirements for this form of detector are negligible.

For the receiving relay a sensitive, multi-winding, polarized telegraph receiving relay is used which requires a current of only a few milliamperes in the operating windings. Two other windings are connected to a local accelerating circuit in accordance with the well-known Gulstad (see "Vibrating Cable Relay," K. Gulstad, *Elec. Rev.*, London, v. 42, 1898; v. 51, 1902) vibrating relay circuit. This tends to insure positive action of the sensitive receiving relay. Furthermore the Gulstad circuit, due to its adjustable vibratory nature, is especially suited for printer telegraph operation. Still another set of windings is used to bias the relay electrically.

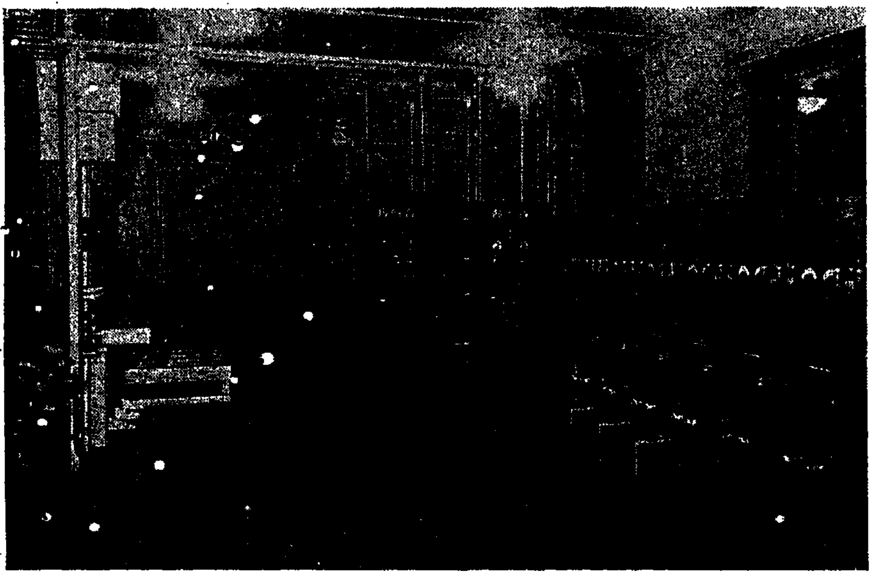

**Fig. 8. New York terminal layout of New York-Washington carrier telegraph system**

Carrier bays for 6 of the 10 channels may be seen at the right

SYSTEM PERFORMANCE

In view of the existing printer plant associated with carrier facilities, a band width capable of handling a 30-cycle dotting speed is all that is necessary to meet present requirements. With the channel bands adjusted for this type of service, it is possible to handle 2-channel multiplex, start-stop, or manual signals commercially. Maximum commercial traffic capability of a 10-channel system operating 4-wire on a 30-cycle basis and working a 2-channel multiplex on each carrier channel as well as on the 4 physical wires, is 3,360 words per min.; 2,400 words of this total is over the carrier. Naturally, a record communication network embodying 2 different types of printer service, along with hand speed telegraph service, thereby is limited in the number of cases where the maximum word capacity of a carrier system can be utilized. For the application at hand, it was more important to standardize the use of carrier channels capable of handling any combination of existing telegraph service used in the present plant.

For the present, carrier systems are operated over existing No. 9 AWG (114.4 mil) copper line wires. This system, even when comprising a complete complement of 10 channels will span distances from 50 to 510 miles (80.5 to 820.6 km) economically and effectively without repeaters. When repeaters are required, they may be spaced up to 275 miles (442.5 km) apart. Each amplifier of a 4-wire repeater has a maximum gain of 28 db and is capable of handling the combined outputs of all channels. Satisfactory operation over a 10-channel system has been demonstrated experimentally over artificial lines through as many as 8 repeaters in tandem, equivalent to a New York-San Francisco system.

As has been stated previously, the inherent operating characteristics of all channels are uniform. An oscillogram showing over-all telegraph transmission over a typical carrier channel is shown in Fig. 5. The telegraph signal transmitted consisted of 30-cycle reversals. The quality of the telegraph transmission may be observed by noting the freedom from bias on comparing traces A and C.

Characteristics of the transmitting shaping networks and of the receiving selecting circuits are shown in Fig. 6. Transmission curves of the receiving selecting circuits arbitrarily show relative discrimination against only the adjacent channel bands. However, the attenuation of the coupled tuned circuit type of selecting circuit employed inherently increases for departures further and further away from the resonant frequency. In order to show this more clearly a characteristic curve of a 1,500-cycle channel receiving selecting circuit is given in Fig. 7; this is typical of the other selecting circuits covering the entire frequency allocation on either side.

Inherent transmission characteristics of the overall channels are suited particularly well to printer operation. Transmission changes as great as ±6 db in the over-all channel equivalent, caused by power or line equivalent variations, will not upset the operation of the printers when initially lined up to operate in the center of the printer range. Printer ranges over the carrier channels are nearly as good as the local ranges attainable on short-circuit.

CONCLUSIONS

Performance data show that the particular carrier telegraph system described fulfils to a practical extent the general requirements set down earlier in this article as an ideal to be approached. This should be evident when it is considered that:

1. Each carrier channel is capable of handling commercially 2-channel multiplex signals at 60 words per multiplex channel, for which speed the apparatus was initially adjusted. Only relatively simple adjustments are required to accommodate signalling speeds suitable for 3- or 4-channel multiplex operation if desired.
2. On the New York-Washington system standard 2-channel multiplex equipment has been operated at the 60-word rate on all of the 10-carrier channels without discrimination.
3. Stability of the carrier system may be judged by the lack of service interruptions over extended periods of time with a simultaneous load of 9 2-way 2-channel multiplex circuits and 1 2-way teleprinter circuit.
4. Channel equipment has been designed to provide economically a large degree of flexibility. It is possible not only to interchange equipment but, at the same time, to secure uniform telegraph transmission at all channel frequencies. These advantages are due mainly to the adjustable features incorporated in the single unit design of the shaping networks and selecting circuits.
5. The introduction of this carrier system into the telegraph plant has not imposed any additional restrictions on the inside or outside plant facilities. An example of this is the retention of the d-c 2-channel multiplex operation, with ground return, over the same wires upon which the carrier system is superimposed.

# Direct Solution of Coupled Tuned Circuits

**A method has been developed for computing easily and accurately the transmission characteristics of a coupled tuned circuit under practical operating conditions. While especially applicable to communication circuits, the method is said to be applicable to all circuits of this general type.**

By
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COMMON PRACTISE today for determining the transmission properties of a selecting circuit is first to assume the circuit to be terminated in an infinite number of recurrent identical selecting circuits and then to treat it much as if it were a portion of an infinitely long line having smoothly distributed constants. Such a method has the advantage of requiring less labor than ordinarily would be involved in applying Kirchoff's laws to the circuit in place, but the assumption often leads to large errors and requires the application of several correction factors for each individual point of the transmission characteristic. The labor can be reduced substantially, however, without resorting to this assumption; the manner in which it can be done is the subject of this article. Only recurrent coupled tuned circuits employing magnetic and capacitive coupling will be treated in detail.

## General Theory

The general theory will be limited to repeated identical networks operating between arbitrary terminations. Also, for convenience, the networks will be assumed to be symmetrical and composed of linear impedances, and the terminations equal to each other.

Referring to Fig. 1, let $Z = Z_X + Z_M$, first of all suppose the terminals 1–2 to be connected by short wires to 3–4. Call the current which flows $I_0$; then $I_0 = E/2Z_T$. The current $I_0$ is therefore the current which flows in the output circuit when no circuit entailing a loss is interposed. The attenuation ratio will be expressed as $I_0/I$ where $I$ is the output current flowing under any conditions for the same value of $E$. Furthermore, let $a_n$ represent this ratio where the subscript $n$ indicates the number of symmetrical networks interposed in any particular case; $a_0 = 1$ may be written immediately. Proceeding,

$$a_1 = \frac{E/2Z_T}{\dfrac{E \cdot Z_M}{(Z_T + Z)^2 - Z_M^2}} = \frac{(Z_T + Z)^2 - Z_M^2}{2\,Z_T\,Z_M}$$

Put $a_1 = A$ for the time being; by proper arrangement, then,

$$a_2 = \left[\frac{2Z}{Z_M}(A) - 1\right] \text{ or } (BA - 1) \text{ where } B = \frac{2Z}{Z_M} \text{ and}$$

likewise $a_3 = [B(BA - 1) - A]$ and so on. In general, it may be proved that

$$a_0 = 1$$
$$a_1 = A$$
$$a_2 = BA - 1 = Ba_1 - a_0$$
$$a_3 = B(BA - 1) - A = Ba_2 - a_1$$

and

$$a_n = Ba_{n-1} - a_{n-2} = Ba_{n+1} - a_{n+2} \qquad (1)$$

Equation 1 is perfectly general for the case assumed and is an exact solution. It is the fundamental equation upon which the present method is based. It remains only to express $A$ and $B$ in simple terms for any particular case to establish the ease and utility of the method. This will be

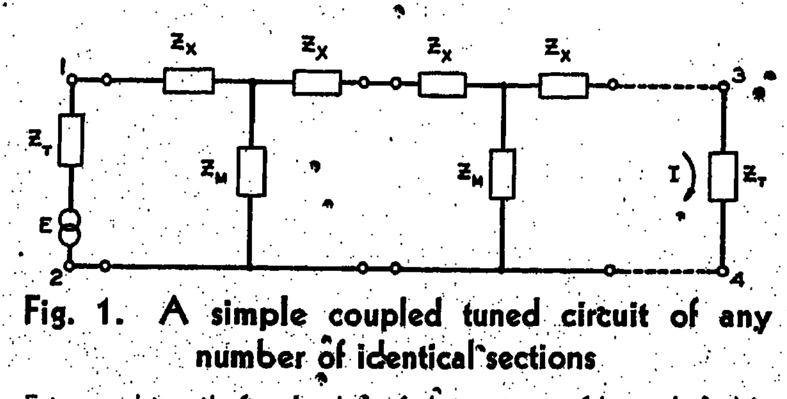

**Fig. 1. A simple coupled tuned circuit of any number of identical sections**

E is an arbitrarily fixed value of alternating emf but adjustable as to frequency; $Z_T$ and $Z_T$ are equal terminal impedances; and $Z_X$ $Z_X$ and $Z_M$ included between 2 pairs of terminals compose each symmetrical network section

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Full text of "Direct Solution of Coupled Tuned Circuits," presented at the A.I.E.E. winter convention, New York, N. Y., January 25–29, 1932. *Pamphlet copies not available.*

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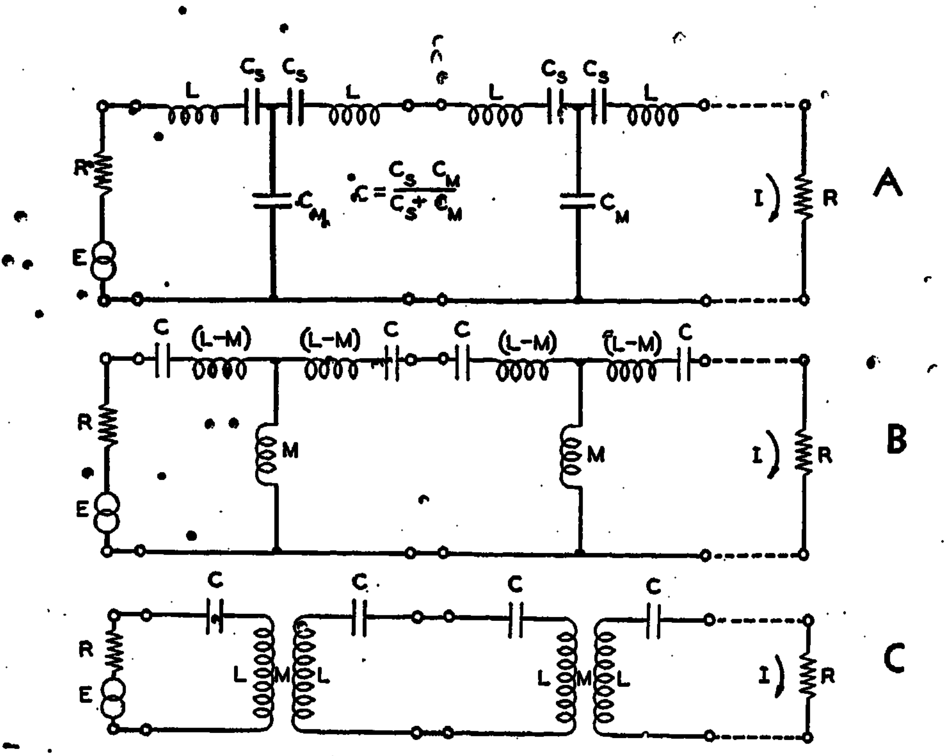

Fig. 2. Typical coupled tuned circuits

done using the well known coupled tuned circuits for illustration.

THEORY APPLIED TO COUPLED TUNED CIRCUITS

A capacitively coupled tuned circuit terminated in equal resistances $R$ is represented in Fig. 2A. Fig. 2B and its equivalent 2C represent magnetically coupled tuned circuits likewise terminated in equal resistances $R$. For the time being $L$ and $C$ will be considered as pure reactances.

In what follows let

$f$ = any frequency

$f_0 = \frac{1}{2\pi\sqrt{LC}}$, the frequency of series resonance

$\omega = 2\pi f$

$K = \frac{M}{L}$ and $\frac{C}{C_M}$, the coefficient of coupling

$b = \frac{f}{f_0}$ with capacitive coupling and

$b = \frac{f_0}{f}$ with magnetic coupling

$R = 2\pi f_0 M$ and $\frac{1}{2\pi f_0 C_M}$ for magnetic and capacitive coupling, respectively.

First consider the case of capacitive coupling as shown in Fig. 2A. Then

$$A = \frac{\left[R + j\left(\omega L - \frac{1}{\omega C}\right)\right]^2 + \left(\frac{1}{\omega C_M}\right)^2}{-j2R \cdot \frac{1}{\omega C_M}}$$

Note that

$\left(\omega L - \frac{1}{\omega C}\right)$ may be transformed to $\frac{1}{\omega C}\left(b^2 - 1\right)$

so that

$$A = -\frac{(b^2 - 1)}{K} + j\left[\frac{b}{2} + \frac{1}{2b} - \frac{1}{2b}\left(\frac{b^2 - 1}{K}\right)^2\right] \tag{2a}$$

and

$$B = j\frac{\left[2\left(\omega L - \frac{1}{\omega C}\right)\right]}{-j\frac{1}{\omega C_M}} = -2\left(\frac{b^2 - 1}{K}\right) \tag{3a}$$

$\left(\omega L - \frac{1}{\omega C}\right)$ may be transformed to $-\omega L(b^2 - 1)$ so that when the coupling is magnetic,

$$A = -\left(\frac{b^2 - 1}{K}\right) - j\left[\frac{b}{2} + \frac{1}{2b} - \frac{1}{2b}\left(\frac{b^2 - 1}{K}\right)^2\right] \tag{2b}$$

and

$$B = -2\left(\frac{b^2 - 1}{K}\right) \tag{3b}$$

There are a number of interesting things to observe about eqs 2a, 3a, 2b, and 3b. In the first place, nothing more is involved that the frequency ratio $b$ and the coefficient of coupling $K$. This simple form is achieved without approximations. For a given value of $K$ these equations show that the attenuation-frequency and phase shift-frequency characteristics are the same in magnitude for all values of capacity and inductance having these configurations, providing the frequency is expressed in terms of the frequency ratio $b$. For given values of $K$ and $b$ the phase shift for magnetic coupling is opposite to that for capacitive coupling. $K$ by definition may have values from 0 to 1. In Fig. 3 are shown a family of curves for $a_1 = A$, or one coupling element with the frequency ratio $b$ and attenuation loss in db as coordinates for several values of $K$. Corresponding phase shift curves are shown in Fig. 4.

It may be seen that the high or low pass selecting circuit is the special case of $K = 1$ for the magnetically or capacitively coupled circuit, respectively. The locus of critical frequency ratio also is shown. These frequency ratios are those at which the steepness of the attenuation frequency ratio curve generally passes through a maximum resulting in low attenuation decreasing rapidly to zero in one direction and increasing rapidly to higher values of attenuation in the other. Quantitatively these frequency ratios are given by setting $(b^2-1)/K = \pm 1$ since the expression occurs as a square in the case of $a_1 = A$ and in still higher powers as $n$ is assigned higher values in $a_n = Ba_{n-1} - a_{n-2}$.

In other words $(b^2-1)/K$ becomes very small quickly when given absolute values less than 1 and increases quickly when given values greater than 1. Therefore $b_1, b_2 = \sqrt{1 \pm K}$ determines the critical frequency ratios which are those between which the structure transmits with little or no attenuation to the comparative exclusion of the range beyond. Similar families of curves could be shown for additional circuit sections and they would reveal a comparatively greater exclusion at the frequency ratios beyond the critical.

By substituting values of $A$ and $B$ found in eqs 2a, 3a, 2b, and 3b in eq 1, the magnitude and phase angle (with respect to the impressed $E$) of the attenuation ratio can be computed exactly and readily for values of $b$, $K$, and $n$. To reduce the labor still more a nomographic chart (Fig. 5) has been prepared to compute the values of the expression $b^2-1/K$ which occurs quite frequently in the formulas for the attenuation ratios.

$$\text{Let } p = \frac{b^2 - 1}{K} \tag{4}$$

Substituting in eqs 2a and 3a

$$A = -p + j\frac{1}{2}\left[b + \frac{1}{b}(1 - p^2)\right] \tag{5a}$$

and

$$B = -2p \tag{6a}$$

Substituting in eqs 2b and 3b

$$A = -p - j\frac{1}{2}\left[b + \frac{1}{b}(1 - p^2)\right] \tag{5b}$$

and

$$B = -2p \tag{6b}$$

The chart in Fig. 5 may be used to solve eq 4 since a straight line connecting $b$ and $K$ will cut the $p$ scale in a value which satisfies the equation.

Transmission characteristics for structures having more than one reactance network interposed may be computed by substituting in eq 1; for example

$$a_0 = 1$$

$$\left.\begin{aligned} a_1 &= -p \pm j\frac{1}{2}\left[b + \frac{1}{b}(1 - p^2)\right] \\ a_2 &= -2p(a_1) - a_0 \\ a_3 &= -2p(a_2) - a_1 \\ &\text{etc., where } A = a_1 \text{ and } B = -2p \end{aligned}\right\} \tag{7}$$

The upper part of the double sign applies to capacity coupling; the lower, to magnetic coupling. Values of $a_n$ in general will be of complex form or $a_n = \bar{a}_n/\underline{\varphi_n}$; $\varphi_n$ will be the phase shift with reference to the impressed emf and $\bar{a}_n$ may be expressed in decibels, $a_n$ (db) $= 20 \log_{10}\bar{a}_n$.

So far the structure has been assumed to be terminated in resistances $R$ such that

$$R = 2\pi f_0 M \text{ or } \frac{1}{2\pi f_0 C_M}$$

This corresponds to the condition of maximum energy transfer at resonant frequency $f_0$ and should be found satisfactory in most cases. For some reason one might wish to consider other values of $R$. The present method can be extended quite easily to cover such cases. Call the new value $R'$ and represent it as a function of $R$ such that $R' = hR$. Now

$$\left.\begin{aligned} a'_0 &= 1 \\ a'_1 &= -p \pm j\frac{1}{2}\left[bh + \frac{1}{bh}(1 - p^2)\right] \\ a'_2 &= -2p(a'_1) - a'_0 \\ a'_3 &= -2p(a'_2) - a'_1 \\ &\text{etc., where } A = a'_1 \text{ and } B = -2p \end{aligned}\right\} \tag{8}$$

A set of curves is shown in Fig. 6 illustrating the effect of giving different values to $h$ when $K = 1$. The importance of the termination in its effect on the resulting characteristic is well shown by comparing the curves for $h = 2$ and $h = 1/2$ with the one for $h = 1$. A curve for $h = \sqrt{2}$ which corresponds to a termination of $R = \sqrt{2L/C}$ is shown also to indicate the possibilities of choosing the termination to bring out a desirable shape for the transmission characteristic.

Heretofore, the coils and condensers have been considered as pure reactances; while for certain purposes it may be safe to assume this, of course it is not possible to build them without some resistance. Make this a function of $R$ so that the resistance of one complete mesh is $r = 2dR$. Accordingly

$$\left.\begin{aligned} a''_0 &= 1 \\ a''_1 &= -p(1 + d) \pm j\frac{1}{2}\left[b(1 + d)^2 + \frac{1}{b}(1 - p^2)\right] \\ a''_2 &= -2(p + jbd)a''_1 - a''_0 \\ a''_3 &= -2(p + jbd)a''_2 - a''_1 \\ &\text{etc., where } A = a''_1 \text{ and } B = -2(p + jbd) \end{aligned}\right\} \tag{9}$$

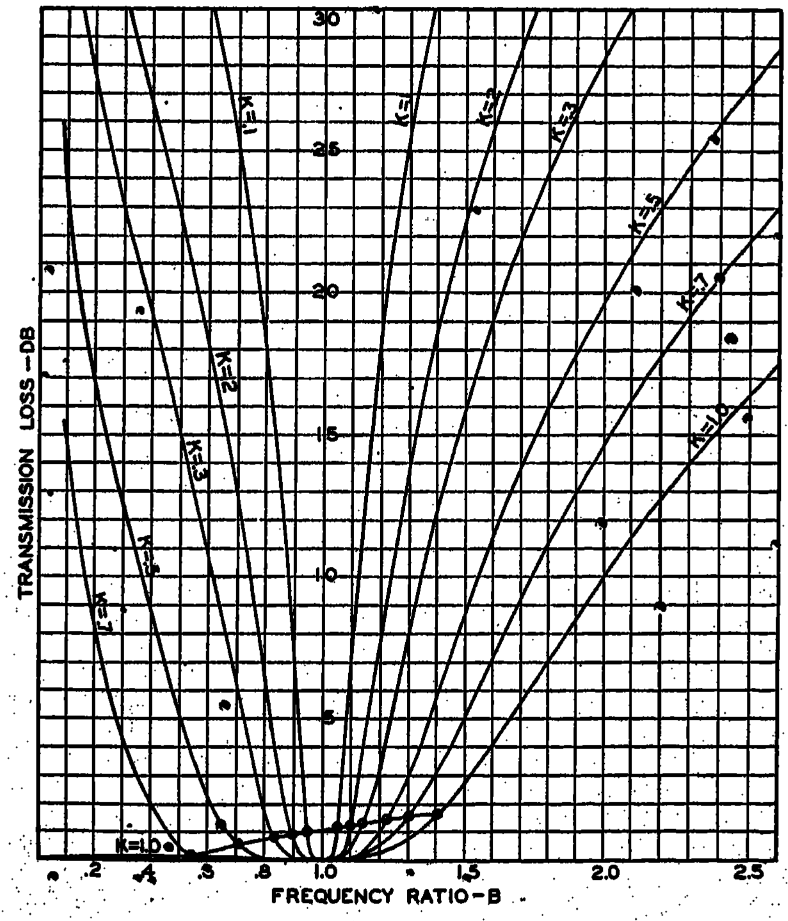

**Fig. 3.** (Left) Attenuation-frequency ratio curves for a tuned circuit having one coupling unit

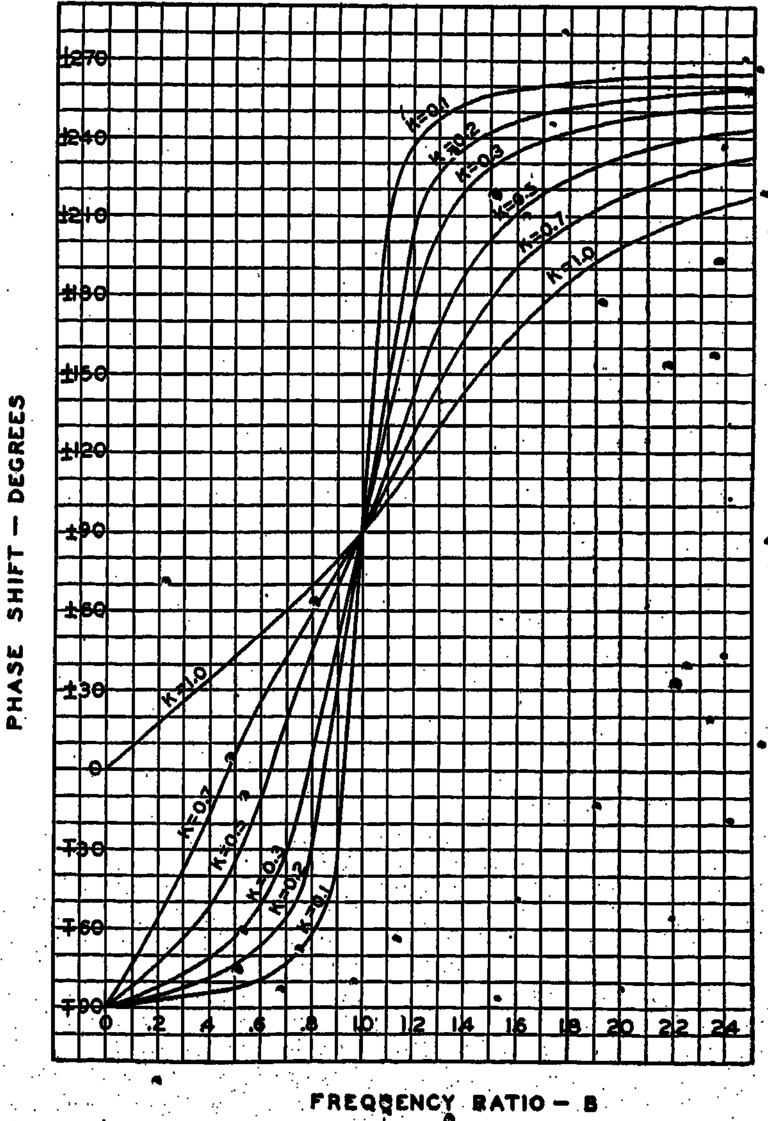

**Fig. 4.** (Right) Phase shift-frequency ratio curves for a tuned circuit having one coupling unit. Use upper sign for capacitive, lower sign for magnetic coupling

The effect of both dissipation and changed termination is given by

$$\left.\begin{aligned}
a'''_0 &= 1\\
a_1''' &= -p(1+d) \pm j\frac{1}{2}\left[bh(1+d)^2 + \frac{1}{bh}(1-p^2)\right]\\
a_2''' &= -2(p+jbd)a_1'' - a_0'''\\
a_3''' &= -2(p+jbd)a_2'' - a_1'''\\
&\text{etc., where } A = a_1''' \text{ and } B = -2(p+jbd)
\end{aligned}\right\} \qquad (10)$$

The foregoing formulas are summarized in Table I.

## DESIGN OF COUPLED TUNED CIRCUITS

The formulas just obtained immediately will suggest methods for designing actual structures for any practical case for they enable the transmission characteristics of this important class of selecting circuits to be readily investigated. To cite an example it will be assumed capacitively coupled tuned circuits are to be used. Data that might be required are, circuit impedances between which the structure will be inserted, the frequency limits between which it is desired to transmit freely, and the attenuation which must be exceeded for certain frequencies outside of the transmitting range.

Call the critical frequencies $f_1$ and $f_2$. Remembering that

$$\frac{b_1}{b_2} = \frac{f_1/f_0}{f_2/f_0} = \frac{\sqrt{1-K}}{\sqrt{1+K}}$$

the value of $K$ and also $f_0$ may be calculated. Suppose the circuit impedances to be equal and represented by $R$. Then the coupling capacity $C_M$ (Fig. 2A) will be found by $C_M = 1/(2\pi f_0 R)$. The value of $C$ will be $C = KC_M$, $C_S = (C \cdot C_M)/(C_M - C)$, and $L = 1/[(2\pi f_0)^2 C]$.

In general the condenser resistance may be neglected and reasonable values of effective resistance of the coils $L$ over the frequency range of interest may be estimated from an abundance of data. Then using the second line of Table I the values of $A$ and $B$ can be computed from which the number of sections required to attain sufficient attenuation outside the transmitting range may be easily determined. Slight adjustments of the band width can be made readily by changes in K and proportional changes in the frequency scale without making a completely new series of computations. The structure then can be assembled with the assurance that the transmission characteristics thus computed will agree closely with measured results.

If the impedances between which the structure is to be inserted are unequal, the inequality may be taken care of by means of a transformer having a suitable impedance ratio or by stepping the circuit impedance up or down in one or more successive meshes remembering that $Z_M = \sqrt{R_1 R_2}$ where $R_1$ and $R_2$ are the circuit impedances of the successive meshes at $f_0$. The condenser and inductance reactance values will be proportional to $R_1$ and $R_2$ in their respective meshes, but the transmission characteristics will remain unchanged so long as the ratio

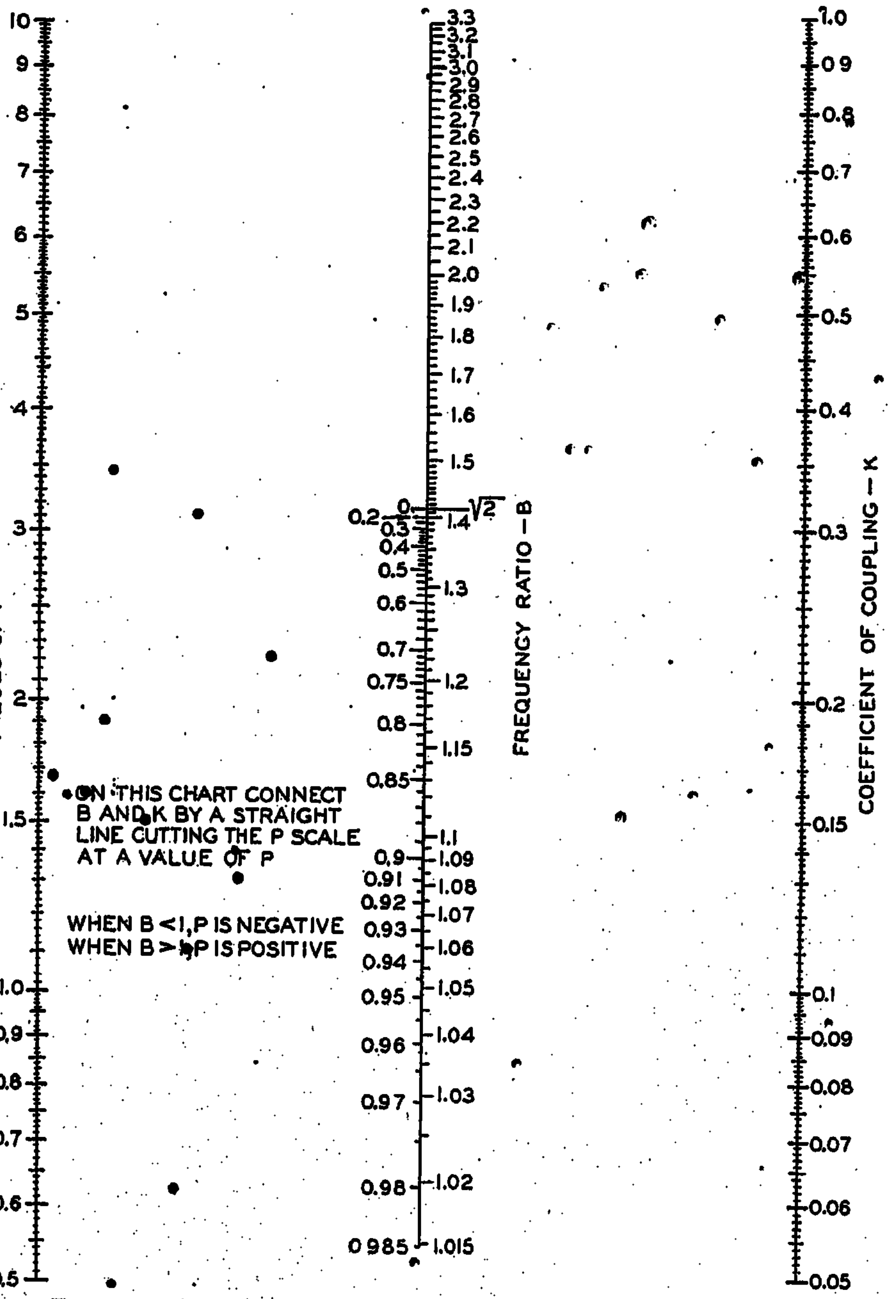

Fig. 5. Nomographic chart for $p = (b^2 - 1)/K$

**Table I—Summary of Formulas Developed**

| Termination | Dissipation (r = resistance per mesh) | A | B | Remarks |
|---|---|---|---|---|
| $R = Z_M$ at $f_0$ | No | $-p \pm j\frac{1}{2}\left[b + \frac{1}{b}(1-p^2)\right]$ | $-2p$ | $a_0 = 1$<br>$a_1 = A$<br>$a_2 = BA - 1$<br>$a_3 = B(BA-1) - A$<br>etc.<br>$a_n = Ba_{n-1} - a_{n-2}$ |
| $R = Z_M$ at $f_0$ | $r = 2dR$ | $-p(1+d) \pm j\frac{1}{2}\left[b(1+d)^2 + \frac{1}{b}(1-p^2)\right]$ | $-2(p+jbd)$ | |
| $Z_T = hR$ | No | $-p \pm j\frac{1}{2}\left[bh + \frac{1}{bh}(1-p^2)\right]$ | $-2p$ | |
| $Z_T = hR$ | $r = 2dR$ | $-p(1+d) \pm j\frac{1}{2}\left[bh(1+d)^2 + \frac{1}{bh}(1-p^2)\right]$ | $-2(p+jbd)$ | |

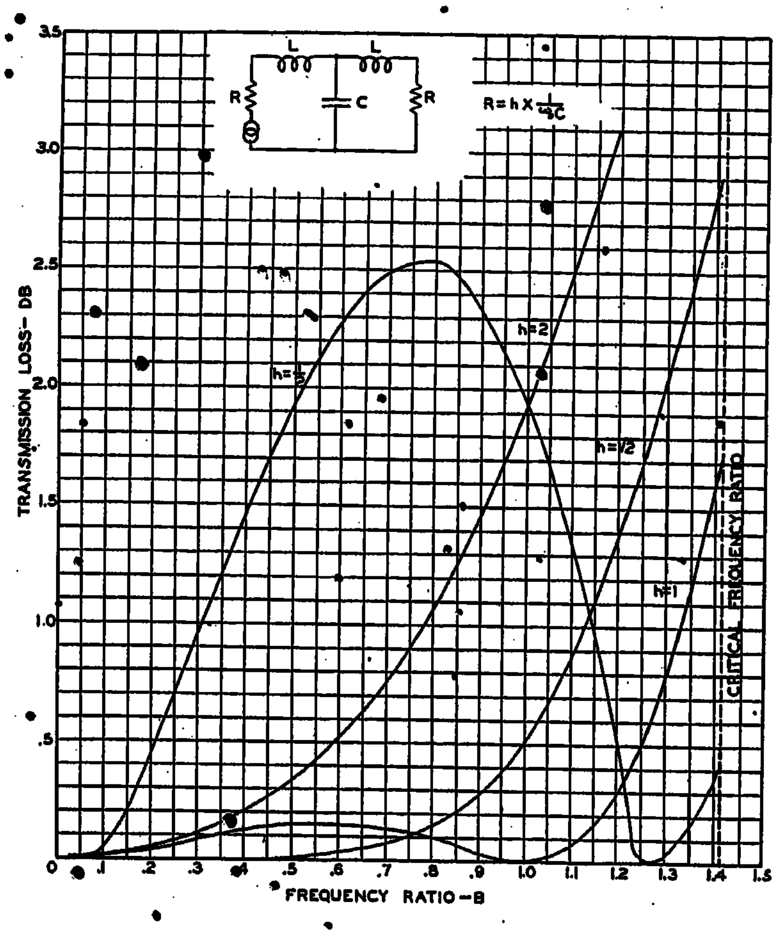

**Fig. 6.** (Left) Attenuation-frequency ratio curves showing effect of different terminations

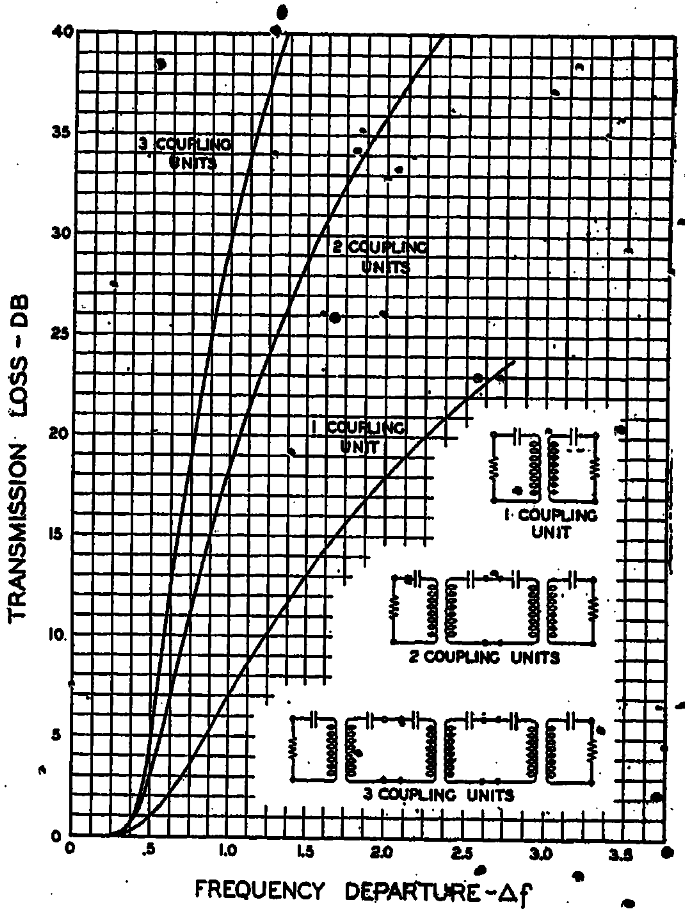

**Fig. 7.** (Right) Attenuation-frequency departure curves for 1, 2, and 3 coupling elements

of reactance to resistance of the different size coils is the same.

## APPROXIMATIONS

Ordinarily, where many circuits of this kind are to be designed it would be convenient to have families of curves plotted covering the range of variables most often desired and interpolate for particular values. It might be desirable, however, to make a rough curve using approximating methods. Many ways suggest themselves but a few which may be helpful will be indicated. The loss in transmitting range, for example, may be gaged from the loss at the frequency $f_0$ which in the case of no dissipation is zero db. Where there is dissipation, it is very closely equal to 20 $\log_{10}[(2R + \Sigma r)/2R]$ db since $r$ is nearly always small compared with $R$. In the attenuation range $r$ usually can be neglected. Moreover, if the attenuation is appreciable (say 10 db or more) for one section, the attenuation for additional sections will be given by adding for each additional section 20 $\log_{10}(2p)$ db to the db attenuation of one section.

It is interesting to consider the case of radio frequency tuned circuits where the fractional change in frequency over the range of interest is extremely small even though it involves traversing a comparatively large number of absolute cycles per sec. Referring to eqs 2a and 2b

$$a_1 = -\left[\frac{b^2-1}{K}\right] \pm j\left[\frac{b}{2} + \frac{1}{2b} + \frac{1}{2b}\left(\frac{b^2-1}{K}\right)^2\right]$$

Assume that $b = 1 \pm \Delta b$ and that $\Delta b$ is very small compared with unity. Whence

$$\left(\frac{b}{2} + \frac{1}{2b}\right) = 1 \text{ approximately}$$

$$(b^2 - 1) = \pm 2\Delta b = \pm\frac{2\Delta f}{f_0} \text{ approximately}$$

Substituting

$$a_1 = -\frac{\pm 2\Delta f}{f_0 K} \pm j\left[1 - \frac{1}{2}\left(\frac{\pm 2\Delta f}{f_0 K}\right)^2\right]$$

or in absolute magnitude

$$\bar{a}_1 = \sqrt{1 + \frac{1}{4}\left(\frac{\pm 2\Delta f}{f_0 K}\right)^4} \text{ approximately}$$

The limiting frequencies of free transmission are derived as before by letting $\pm 2\Delta f/f_0K = 1$. The band width is then $W = f_0K$. Let $f_0K = 1$ in the approximate equation and plot $\bar{a}_1$ in decibels against frequency departure $\Delta f$. Such a curve is shown in Fig. 7 for one coupling unit, but since it is symmetrical about $\Delta f = 0$ only half is drawn. To use the curve look up the attenuation corresponding to $\Delta f$ and then multiply the value of $\Delta f$ by the band width $W$ which gives the actual departure in cycles per second from $f_0$ having that attenuation.

As a specific example, suppose it is desired to investigate the selectivity curve for a coupled tuned circuit with one coupling element such that it will transmit a band of 5 kc at a resonant frequency of 1,500 kc, i. e., from 1,502.5 kc to 1,497.5 kc. Since $W = f_0K$, $K = 1/300$. Then multiply the abscissas of Fig. 7 by 5 kc and the curve for one coupling unit automatically becomes the selectivity curve with abscissas in kilocycles off resonance. Actual values for the coils and condensers depend upon the circuit impedance and are determined readily in the manner previously shown.

These approximations may be extended to tuned circuits of more than one section. Take 2 sections for example.

$$B = -2\left(\frac{b^2-1}{K}\right) = \frac{2\Delta f}{f_0 K} \text{ approximately}$$

In $a_2 = BA - 1$ substitute the approximate expressions for $A$ and $B$, whence

$$a_2 = \left[2\left(\frac{2\Delta f}{f_0 K}\right)^2 - 1\right] \pm j - 2\left[\frac{2\Delta f}{f_0 K}\right]\left[1 - \frac{1}{2}\left(\frac{2\Delta f}{f_0 K}\right)^2\right]$$

The absolute magnitude

$$\bar{a}_2 = \sqrt{1 + \left(\frac{2\Delta f}{f_0 K}\right)^6}$$

Here again the band width is $W = f_0K$ and a similar selectivity curve is drawn in Fig. 7 for 2 coupling units. This curve may be used in exactly the same manner as indicated for the first curve. The same is true of the curve for 3 coupling units. Indeed, all of the curves are drawn to the same scale of frequency and are directly comparable in regard to their selecting properties. It is possible, therefore, to see at a glance the selectivity to be expected from 1, 2, or 3 sections of either capacitively or magnetically coupled tuned circuits providing $K$ is small enough so that $b$ need depart only slightly from unity to cover the frequency range of interest. It is assumed also that $R = Z_M$ and dissipation is negligible. They do, nevertheless, afford considerable information for a small amount of effort, since there is no special advantage in using a different value of $R$ and dissipation will cause a more or less rounding off at the critical frequencies, an exceedingly small range of frequencies to investigate more precisely. No doubt, other ways of approximating will suggest themselves.

It was noted earlier in the paper that the coupled tuned circuits were to be treated as an example of the general scheme based upon eq 1. For other types of structures the first step would be to convert the expressions for $A$ and $B$ in terms of the structure into the simple form of ratios and proceed along the same line as shown here for coupled tuned circuits.

# Engineering Progress—Help or Hindrance?

**Engineering progress is said to be neither good nor bad; it may help man or hinder him, depending upon how it is used. This is the fourteenth article of the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"**

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NOT ALL progress is real gain. If we increase our needs at the same rate as we increase our facilities, there is no *real* gain. We have means to travel quickly, but why should we travel quickly? Mainly because modern life needs it; but we have to travel much more and the total delay and discomfort may be greater.

While some diseases are much attenuated, new ones are due to the new way of living. Would it be real progress to find a radical method of curing tuberculosis? Yes, given the present conditions; but are not these conditions the main reason why tuberculosis became so widespread? Surgical methods are much improved, but are most cases not due to our way of living: accidents, lack of exercise, unsuitable food?

What is happiness? If one considers his own life, he will find that the notion "happy" is relative for what makes us relatively happy for a time is not necessarily of real benefit. Real happiness should last, and can be procured only by what is really good; it is practically independent of material conditions—an abandoned, poor, sick man may be happy. Experience tells us that no *material* good has ever given true and lasting satisfaction. Every time we reach such a goal we find that it is not the thing we expected.

Experience of past ages shows that no civilization, no culture, no progress, no improved means of communication, no form of government, in short, no improvement of the outer influences, can bring peace and make man really happy. The great obstacle is man himself. He must change individually. The famous Claude Bernard used to say:

> "Science has made great progress; man's passions remain the same. . . . Science does not change instinct, it reinforces it and increases its strength."

Engineering progress is neither good nor bad in itself. Engineering is concerned principally with the lower class of good. Material conditions have been much improved, particularly for the country people; but we may ask whether these conditions could not have been improved sufficiently in a more efficient way by a change in general organization even without modern progress. For the higher class of good, engineering progress may be a help, but at the same time a hindrance.

## RIGHT USE OF ENGINEERING PROGRESS

Engineering progress and scientific discoveries show us more clearly the marvels of creation and should lead us logically to the invisible and absolute things. Many men through whom this progress was made possible could say with Faraday:

> "Yet even in earthly matters I believe that the invisible things of Him from the creation of the world are clearly seen, being understood by the things that are made, even His eternal power of Godhead; and I have never seen anything incompatible between those things of man which can be known by the spirit of man which is within him and those higher things concerning his future, which he cannot know by that spirit."

Engineering progress helps to manifest man to himself. A child shows his childliness by choosing his sort of good; a man can likewise recognize his mental or spiritual position by what he considers as good. The way to real progress is understanding and acknowledgment of one's real position. If experience (and engineering developments are an important factor) teaches man that he is far from perfect and that his own efforts even by giving marvelous results *in their proper sphere*, cannot lift him above himself, and that he needs make use of a power belonging to a higher sphere, he will make real progress and come to real and lasting happiness.

### WRONG USE OF ENGINEERING PROGRESS

Engineering progress may hinder us from reaching the highest good. In general, modern nervous life gives fewer opportunities to examine calmly the problems of life; it draws all attention to material things. Such progress may in another way have a harmful effect. Man may consider himself as the most superior being. He may consider his achievements in the material sphere as proof of his own capabilities in any sphere of existence. He may expect to come, through culture, science, and arts, to a state of universal peace and real happiness. If he thinks this way and places himself above all, he will pass through bitter experiences; then engineering developments will have been misused. Observation shows that they often are misused; but that is the fault of man, not of engineering progress.

Great progress has been made in material things. However, as many facilities are needed by the new conditions, the final gain is not so large as may be estimated at first sight. Further, any progress in the material sphere can give only some relative and temporary happiness. Absolute and lasting happiness can have its source only outside of the human sphere and in order to attain such a state of happiness, the inner man must be changed. Material progress may help if rightly used, but also may hinder if wrongly used. Pride in his own achievements may blind man to the extent that he does not see his real needs and is kept from looking for real happiness where it can be found.

**Editor's Note: Pursuant to the invitation of the Engineering Foundation, the editors will be happy to receive comments, criticisms, or discussions pertaining to this or other articles published in this series.**

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# Vibration in Electrical Conductors

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**Laboratory tests using water as a medium indicate that the vibration of a conductor used for transmitting electric power can be diminished materially by the use of different shapes of cable cross-sections. The investigation shows further that of the various specimens tested, cables having a triangular cross-section show the least tendency to vibrate.**

BECAUSE of the general increase in unit working loads as well as in the sizes of conductors on electric power transmission lines, vibration of these conductors has become a serious problem. Overhead conductor vibration probably was reported first in 1923 as deteriorating the mechanical characteristics of conductors, by some of the power companies of California. These vibrations seldom have an amplitude exceeding 2 in. Node lengths vary considerably and the frequency is of the order of from 10 to 100 cycles per sec.

Numerous mechanisms and appliances have been suggested for overcoming conductor vibrations, and some of these function very well indeed. However, such devices always are subject to the criticism that ultimately they may account for more harm than good. At the same time if the cause of the vibration can be determined, and preventives applied at the source, there will be then but little danger of trouble occurring later at some unexpected point.

Following reports of a field observation from a Pacific Coast power company, to the effect that a 3-strand cable did not vibrate as much as a standard cable,[6] also that a single strand wrapped about a cable seemed to reduce the vibration,[7] it was thought that the problem might be solved by modifying the conductor sections rather than by adding reenforcements or dampers. Studies made later by Thoma[8] confirmed this assumption, and showed that the section of the cable did play an important part in the vibration characteristics. It was thought that by upsetting the symmetry of the conductor section, eddies formed on the lee side of the conductor would be disrupted. This is explained in the following paragraphs.

### THEORY OF NON-SYMMETRICAL SECTIONS

A $^5/_8$-in. diameter round rod with a $^1/_8$-in. diameter wire spiralled about it, as shown in Fig. 1, has been

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Based upon "Vibration and Fatigue in Electrical Conductors" (No. 32-69) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932.

selected to indicate the complicated system of frequencies brought about by the eddy formation at several successive cross-sections along the cable. Balancing of the eddy forces is demonstrated at individual pairs of cross-sections. A $^5/_8$-in. plain round rod is examined also for comparison; as may be seen, there is no balancing action in this type of conductor.

Four variables that modify the resultant eddy action behind the rod and wire are introduced in each individual cross-section, namely: (1) frequency, (2) phase, (3) amplitude, and (4) neutral vibration plane. Each of these is studied in detail as follows:

1. Frequencies were calculated from the Relf and Ower[1] formula.

$$\text{Frequency} = \frac{V}{D} \times \phi\left(\frac{VD}{e}\right)$$

Assuming constant velocity of flow, the frequency is proportional to the diameter of the section; hence varying this diameter varies the frequency. In the case shown in Fig. 1, variation is brought about by spiralling the wire about the rod. The effective diameter of the combination will be the diameter of the rod plus a portion of the diameter of the wire. The diameters only were considered in determining the frequencies; theoretical curves were plotted from these values. These curves then represent, to some scale, the actual frequency of the section.

2. Phase of the vibration of an individual section is governed by the position of the outer wire and has been plotted accordingly in the diagram.

3. Force acting in the direction of vibration is,[5]

$P = KV^2 \times D$ per ft run per lb

where $P$ = force, $V$ = velocity, and $D$ = diameter.

Assuming velocity constant, the force will be proportional to the diameter. The amplitude of the vibration, therefore also will be proportional to the diameter. For each section in the diagram (Fig. 1) the maximum amplitude has been plotted equal to the effective diameter and therefore represents to scale the true amplitude.

4. Vibration will take place about the center of impact of the section; this is offset from the horizontal diameter of the rod, and has been indicated in Fig. 1 by a broken line.

Eddy formation and resulting forces have been plotted for an instantaneous position of the rod and will reverse at periods according to the frequencies involved, as indicated in Fig. 1 by the double arrows for the round rod and by the double wave at cross-section 4. No attempt has been made here to establish the exact mathematical values of the quantities involved, but this is being investigated. The diagram thus illustrates the principle qualitatively, but not quantitatively.

It may be seen that at sections 3 and 7, and at 2 and 6, Fig. 1, the frequencies and amplitudes (therefore forces) are equal but are 180 deg out of phase. They will, therefore, tend to balance one another in the direction of vibration, thus reducing this objectionable feature. In the symmetrical round rod, the eddy formation is identical at each section and no balancing tendency is evident. At section 4 of the combination of rod and wire, an unstable condition is introduced due to the forces on the sections on either side of it tending to move the conductor in opposite vertical directions.

It must be realized that this discussion deals with a small length of cable and with an 8-in. lay of the wire; the 2 boundary sections are separated by 8 in. Similarly, with 3-strand cable the boundary sections would be separated by only $2^2/_3$ in. In practise it is highly probable that over such a small strata in

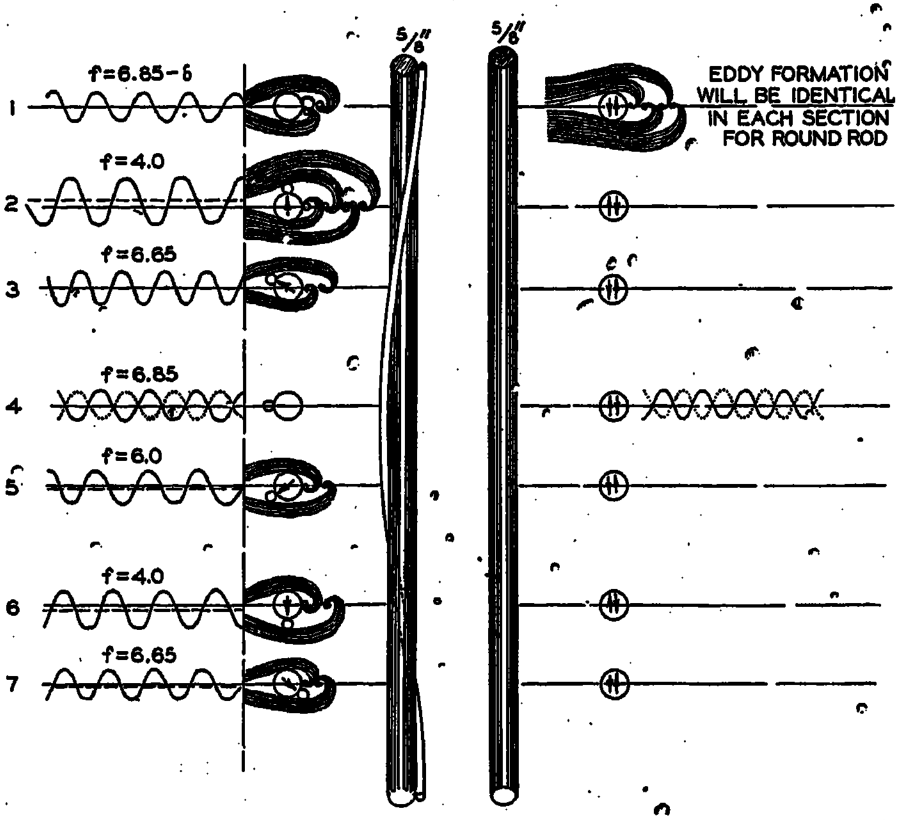


**Fig. 1. Comparative study of eddy formation at the lee side of the stream flow, for uniform and non-uniform specimens**

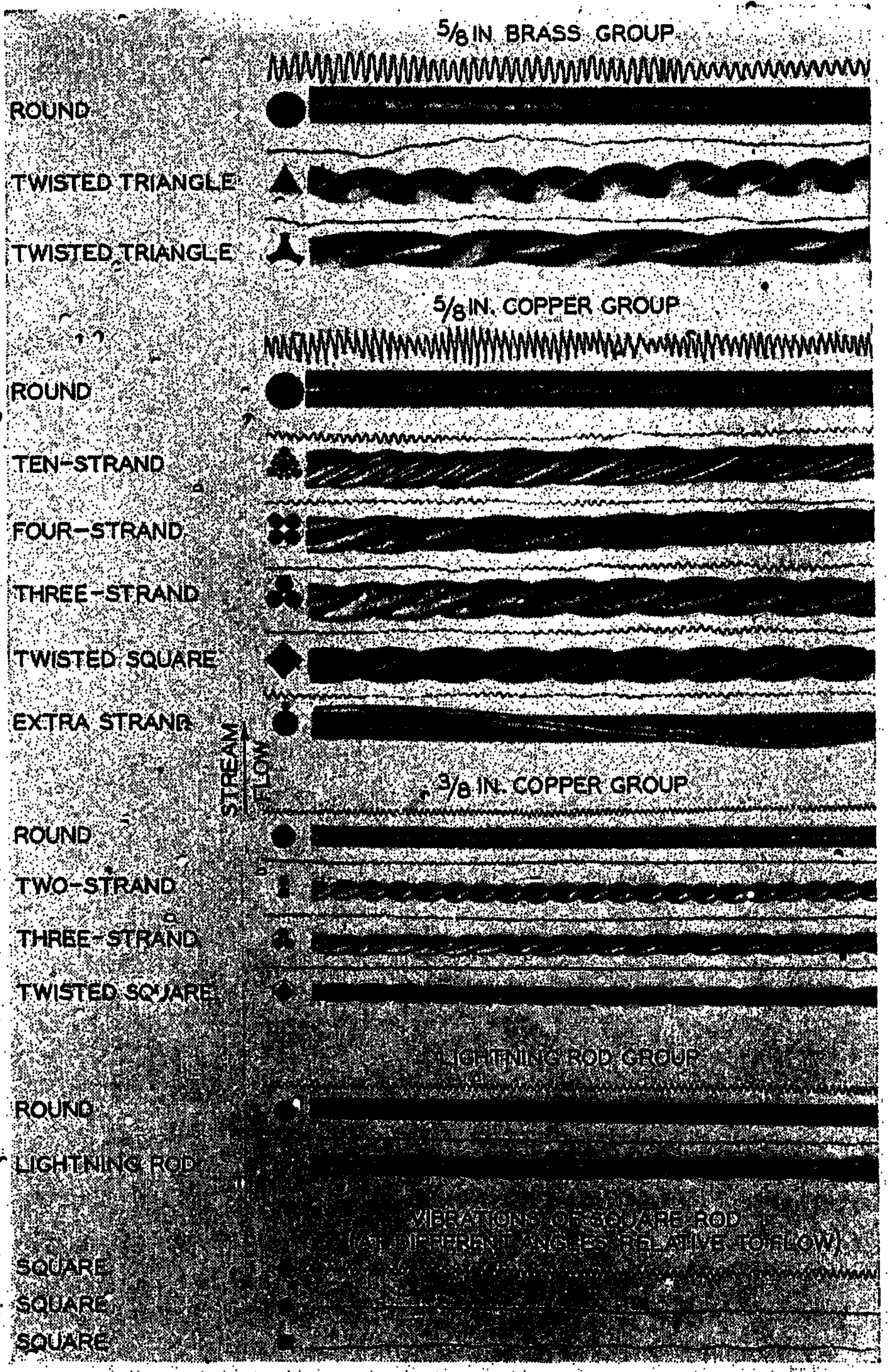


**Fig. 2. Comparative vibration in water of conductors of various sections and types**

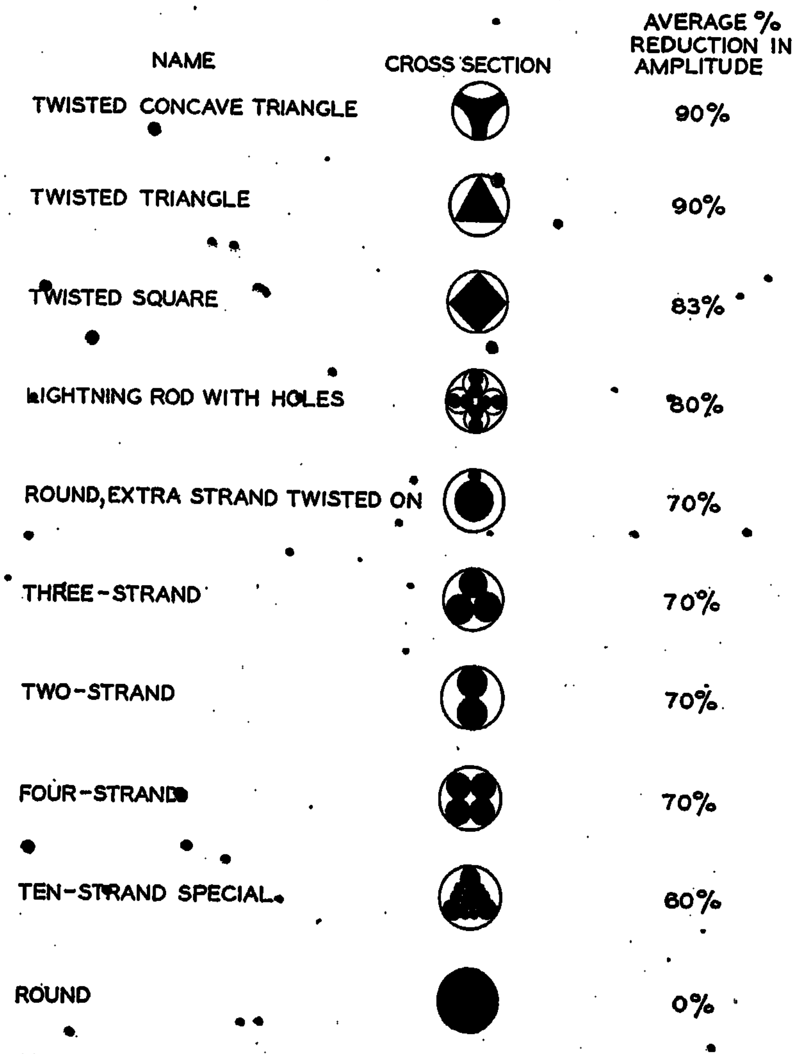


**Fig. 3. Percentage reductions of vibration for conductors of different cross-sections, as observed in water**

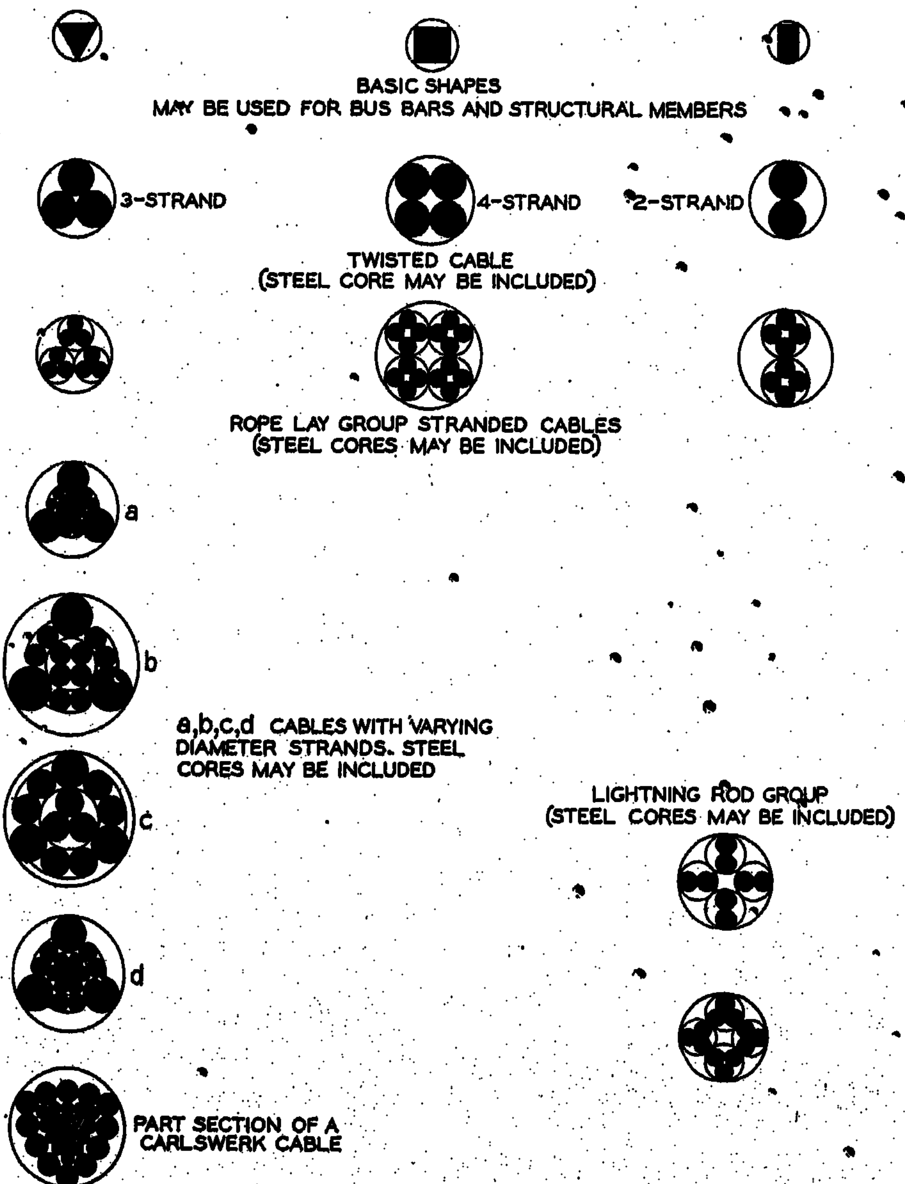

BASIC SHAPES
MAY BE USED FOR BUS BARS AND STRUCTURAL MEMBERS
3-STRAND
4-STRAND
2-STRAND
TWISTED CABLE
(STEEL CORE MAY BE INCLUDED)
ROPE LAY GROUP STRANDED CABLES
(STEEL CORES MAY BE INCLUDED)
a
b
a,b,c,d CABLES WITH VARYING DIAMETER STRANDS. STEEL CORES MAY BE INCLUDED
c
LIGHTNING ROD GROUP
(STEEL CORES MAY BE INCLUDED)
d
PART SECTION OF A CARLSWERK CABLE

**Fig. 4. Desirable cross-sections for cables and buses exposed to light winds**

comparison to the length of the span, wind velocity would be approximately constant.

## Special Sections Available for Study

The single wire spiralled about the rod is impracticable, for on the application of tension the load on the cable becomes eccentric. This analysis, however, points the way to modifying, in a practical way, the fundamentals of vibration in cables. For instance, in a 3-strand cable, this same complication of frequencies would be present, but the tension would be uniformly balanced over the cable section. The 4-strand cable also is a good example and is in common use, more especially in steel wire rope. Almost any sector or acorn shape may be made without much loss of mechanical strength by rolling or hammering the round cable as in 3-phase insulated cables.

As a basis upon which to work, it was decided to make specimens of sections of cables that were statically balanced so that they would not pull eccentrically. The section should, however, be unsymmetrical about the horizontal axis of the cable and at the same time be unsymmetrical for successive sections along the cable; in other words, the section should simulate those characteristics which seemed to interfere with vibration in the wire-wrapped cable. It was evident that as uniform an eddy action could not be expected over a length of these special cables as appears to be the case with standard cables or round rods, with a consequent reduction of the power input from the wind.

## Laboratory Work

Experiments to determine the effect of different cable cross-sections, and the amplitude of vibration, based upon the foregoing assumptions, were carried out in the hydraulic laboratory of the University of Toronto. Experiments and methods used by Doctor Thoma were followed quite closely, water being used as a medium. Specimen conductors of various peculiar shapes were tested at 5 different velocities of water ranging from 4 to 7 in. per sec. The specimen was fastened to a flat steel strap 1 in. by $^1/_{32}$ in. and 5 ft long. This strap was used in preference to the elastic steel rod which Thoma used, as it restricted most effectively any movement in the direction of the flow of water. A light pointer attached to the strap traced the wave motion on a smoke chart attached to the drum of a vibrograph. The specimens were divided into 5 groups, each group having a circular sample as a standard of comparison. Projected dimensions, or effective diameters, of all the specimens within each group were approximately the same, the object being to obtain the same frequencies of vibration. In order that the vibrating system in each group should be as nearly as possible the same, the specimens were made equal in weight and with centers of mass at the same point as that of the standard.

Adjustment for resonance was brought about by varying the length of the strap between the specimen and the clamp until the maximum amplitude of vibration of the strap was obtained. Other sections in the corresponding group were treated similarly. That the required similarity was obtained was evidenced by the fact that in each group adjustment for fundamental resonance of the various samples was negligible and was seldom necessary at all so that the natural frequencies of the systems were approximately identical.

Owing to variations in the speed of the smoke chart, no exact check of the observed frequencies could be made, but the fact that no important adjustments were required within the groups indicates that approximately identical frequencies were obtained in each case. In any case, the final purpose of the experiments was to derive qualitative rather than quantitative results. The design of specimens giving the same vibrating systems within each group (i. e., having the same mechanical impedance) permitted the use of vibration amplitude as a measure of the relative damping.

## CONCLUSIONS FROM HYDRAULIC EXPERIMENTS

Qualitatively the following conclusions may be drawn from the experiments just outlined, pending more practical experiments using air as a medium:

1. As evidenced by the charts shown in Fig. 2, it may be seen that so far as hydraulic experiments are concerned, the twisted triangular section most satisfactorily overcomes the tendency to vibrate.

2. It can be noticed also that practically all the sections tested decreased the amplitude by at least 50 per cent compared with the round rod (Fig. 3). From the results, it would seem advisable to construct a cable having approximately a triangular cross-section. Fig. 4 shows a series of cable sections derived from the basic sections that in the laboratory evidenced a considerable reduction in tendency to vibrate.

3. If these special triangular and rectangular sections prove impracticable in cables, they still may be used in outdoor buses where difficulties of this nature may arise in the future.

## FUTURE INVESTIGATION WORK

Upon the basis of these tests and the conclusions drawn, the following points are proposed or suggested for future investigation:

1. At present special cables approximating triangular cross-sections have been made and are being strung in air to see how closely the hydraulic experiments simulated practical conditions. Three sections have been suggested: (1) the ordinary 3-strand cable which was casually observed in the West as being comparatively free from vibration; (2) a 9-strand cable made up of 3 strands of 3-strand cable with rope lay; and (3) a special 9-strand cable using 2 sizes of strands, the 3 larger strands so placed in the outside layer as to give approximately the desirable triangular effect (Fig. 5). The special rope lay cable introduces a feature which may be of great importance. Due to a characteristic of the stranding, air-gaps that will not collapse under tension have been introduced. The presence of these air-gaps may serve to upset further the sequence of eddies behind the cable.

2. Acting conjointly with so-called "stiction" and "interstrand friction," the elastic properties of the individual strands of a standard cable will tend to modify the vibration. Investigation should be made with the object of segregating these and to determine the comparative importance of the damping in each case. Does interstrand friction absorb any energy at all at the comparatively long radii of curvature found in conductor vibration phenomena?

3. Experiments should be carried out to verify the following predictions made for 2 cables, (1) 6 x 0.2108, 7 x 0.0705, 266,800 cir mils A.C.S.R. "Owl"; and (2) 30 x 0.1059, 7 x 0.1059, 336,400 cir mils A.C.S.R. "Oriole." An attempt was made to predict mathematically the characteristic dimensions of vibration in these two cables and to balance energy input against energy dissipated, the remainder of the energy doing work on the cable at points of discontinuity, such as clamps. Many assumptions had to be made. Initial attempts at measurements in the field were unsatisfactory and this work was temporarily abandoned.

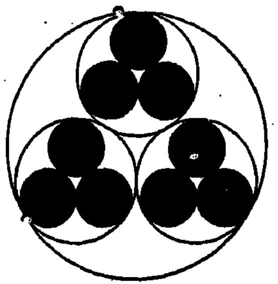
4. A determination of the actuating force per foot length of cable should be carried out. This could be done in a suitable wind tunnel with adjustable elastic supports for the specimen under test.

## PRACTICAL DIFFICULTIES

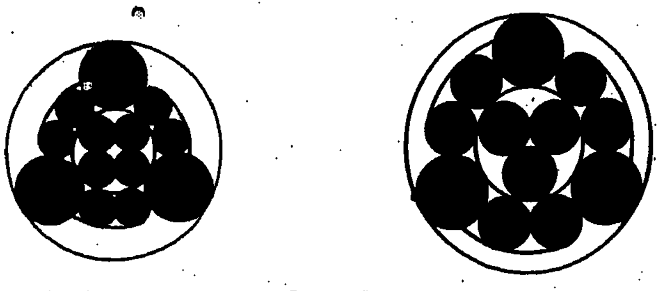
There are many objections to any departures from standard cables such as are indicated by these experiments. It is hoped therefore that so far as vibration is concerned the proposed sections will display new properties which in some cases at least will outweigh practical difficulties, such as standardization.

Some of the possible objections to some of the cross-sections proposed are that the electrical losses may be increased to some extent; the increased diameters would account for greater wind pressures and sleet loadings; difficulty would be experienced in making joints. In addition, 2 sizes of strands in 1 cable would be a digression from the standards, and if more than 1 pass through the stranding machine be required on account of these various sizes of strands, the cable cost would be increased.

Discussions and studies of these details are deferred until there is an opportunity to confirm in a practical way that the vibration amplitudes are suppressed in air, as they have been found to be in water.



ROPE LAY GROUP STRANDED CABLE



TWO CABLES WITH VARYING DIAMETER STRANDS

**Fig. 5. Most practicable cable cross-sections for suppression of vibration**

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# Single-Phase Short-Circuit Torque

The analysis of synchronous machines previously published by Doherty and Nickle is expanded in this article to include the calculation of torque due to single-phase short-circuit. The torque is expressed as the sum of odd and even harmonic series which are simply related to those previously derived for the armature current. The effect of amortisseur windings also is taken into account. As an illustration of the application of the equations, the short circuit torque is calculated for a 100,000 kva generator.

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EXPRESSIONS for the single-phase short-circuit torque of a synchronous machine may be derived from previously published equations for 3-phase short-circuit torque and for single-phase short-circuit currents. These previously published equations are given in a series of articles by R. E. Doherty and C. A. Nickle (namely, SYNCHRONOUS MACHINES—I AND II, A.I.E.E. TRANS., v. 45, 1926, p. 912–42; SYNCHRONOUS MACHINES—III, A.I.E.E. TRANS., v. 46, 1927, p. 1–18; SYNCHRONOUS MACHINES—IV, A.I.E.E. TRANS., v. 47, 1928, p. 457–92; SYNCHRONOUS MACHINES—V, A.I.E.E. TRANS., v. 49, 1930, p. 700–14) particularly on "Synchronous Machines—IV" which gives expressions for the currents resulting from single phase short circuits.

As the present article is based on the theory and equations developed in "Synchronous Machines—IV," the simplifying assumptions made therein are necessarily used here. The most important of these assumptions are that:

1. Saturation is negligible.
2. The open circuit voltage is sinusoidal.
3. Armature and field resistances are negligible except in determining decrements.
4. The short circuit occurs at no load.
5. Synchronous speed is maintained during short circuit.

Throughout the article all quantities are expressed in the per unit system unless otherwise noted; and instantaneous values of voltage, current, mmf, flux linkages, and torque are used.

## GENERAL PROCEDURE

The synchronous machine is considered as having a main field winding in the direct axis and amortisseur windings in both the direct and quadrature axes, thus introducing both subtransient and transient reactances. The general procedure employed in "Synchronous Machines—IV" is used to determine armature current and rotor excitation, except that 3-phase line-to-neutral reactances are used in place of single phase static reactances.

The values of the armature current and mmf, before the effect of the decrements is appreciable, are determined by the open circuit armature voltage, $e_o$, the position of the rotor when short circuit occurs, and the subtransient reactances. The armature mmf is resolved into components over the direct and quadrature axes and is expressed in terms of odd and even harmonic series. The fundamental of the odd series current induces a transient direct current in the direct axis rotor circuits; all other harmonic components induce alternating currents in the rotor windings. Consequently, on short circuit the d-c rotor excitation is increased from the value existing just before short circuit to a new value which includes a component induced in the 2 direct axis rotor windings by the armature current. The decay of the induced d-c components of excitation and that of the odd series component of the armature current are determined by the decrement factors of the rotor windings in the direct axis.

It is assumed that the decay of the unsupported rotor excitation may be represented with sufficient accuracy by 2 decrement factors, one applying to the decay of induced direct currents in the amortisseur winding, and the other applying to the decay of that part of the d-c component of field current which the exciter does not maintain. The "rotor linkage factor," $F$, represents the total rotor linkages at any time after short circuit, as a fraction of the rotor linkage just before short circuit. The following equation gives $F$ as a function of time, in terms of machine constants:

$$F = \frac{x_d'' + x_2}{x_d + x_2} + \frac{(x_d'' + x_2)\,(x_d - x_d')}{(x_d + x_2)\,(x_d' + x_2)}\,\epsilon^{-\sigma_f' t} + \frac{x_d' - x_d''}{x_d' + x_2}\,\epsilon^{-\sigma_f'' t} \qquad (1)$$

where

$x_d$ = direct axis synchronous reactance
$x_d'$ = direct axis transient reactance
$x_d''$ = direct axis subtransient reactance
$x_q''$ = quadrature axis subtransient reactance
$x_2$ = negative sequence reactance = $\sqrt{x_d'' x_q''}$
$\sigma_f'$ = the decrement for the unsupported linkages in the main field, with the armature short-circuited single-phase $\doteq \dfrac{x_d + x_2}{x_d' + x_2}\sigma_o'$
$\sigma_o'$ = the decrement for unsupported field linkages with the armature open circuited
$\sigma_f''$ = the decrement for induced direct currents in the amortisseur on single phase short circuit $= \dfrac{x_d''\,(x_d' + x_2)}{x_d'\,(x_d'' + x_2)}\sigma_a''$

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Based upon "Single-Phase Short-Circuit Torque of a Synchronous Machine" (32-72) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932.

$\sigma_s''$ = the amortisseur winding decrement for 3-phase short-circuit at the machine terminals
(Since in the per unit system time is measured, not in seconds, but in electrical radians traversed at the normal frequency, $f$, the decrements above are $1/(2\pi f)$ times the reciprocals of the respective time constants in seconds.)

The linkages in the short circuited armature winding are maintained, at the instant just after short circuit, by the induced d-c component of armature current. These linkages must decay with the d-c component of armature current. For convenience, an "armature linkage factor," $A$, is introduced. It represents the linkages of the short circuited armature winding at any time after short circuit as a fraction of the maximum linkages of that winding before short circuit. As shown in "Synchronous Machines—IV," the even series components of armature current and the odd series components of rotor excitation are proportional to the d-c component in the armature, so that their decay is also represented by the armature linkage factor, $A$.

The expression for this factor is

$$A = \epsilon^{-\sigma_a t}\cos\alpha \tag{2}$$

where

$$\sigma_a = \frac{3(k^2+1)}{4k^2}\,\frac{r}{x_2}$$

$k$ = 1, for line-to-neutral short circuit
$k$ = $\sqrt{3}$, for line-to-line short circuit
$r$ = the per unit armature resistance, line-to-neutral
$\alpha$ = angular position of the direct axis at the instant of short circuit, measured in the direction of rotation from the axis of the armature winding.

Inserting the armature and field linkage factors $A$ and $F$, respectively, in equations which are given in "Synchronous Machines—IV," the armature current at any time after single phase short circuit may be expressed in finite trigonometric form, as follows:

$$i = \left(\frac{3}{2k}\right)\frac{2e_o[F\cos(t+\alpha) - A]}{H} \tag{3}$$

where

$e_o$ = armature voltage before short circuit
$H = (x_d'' + x_q'') + (x_d'' - x_q'')\cos 2(t+\alpha)$

The equivalent Fourier series expansion is:

$$i = \frac{3}{2k}\left[\frac{2e_oF}{x_d''+x_2}\mathrm{O} - \frac{e_oA}{x_2}\mathrm{E}\right] \tag{4}$$

where

$$\mathrm{O} = \text{odd series} = \frac{(x_d''+x_2)\cos(t+\alpha)}{H}$$
$$= \cos(t+\alpha) + b\cos 3(t+\alpha) + b^2\cos 5(t+\alpha) + \ldots$$
$$= \sum_{n=1,3,\ldots} b^{\frac{n-1}{2}}\cos n(t+\alpha)$$
$$\mathrm{E} = \text{even series} = \frac{2x_2}{H}$$
$$= 1 + 2b\cos 2(t+\alpha) + 2b^2\cos 4(t+\alpha) + \ldots$$
$$= 1 + \sum_{n=2,4,\ldots} 2b^{\frac{n}{2}}\cos n(t+\alpha)$$
$$b = \frac{\sqrt{x_q''} - \sqrt{x_d''}}{\sqrt{x_q''} + \sqrt{x_d''}} = \frac{x_2 - x_d''}{x_2 + x_d''}$$

The short circuit torque is expressed in terms of the components of armature current and rotor excitation in the direct and quadrature axes. The expression in finite trigonometric form is

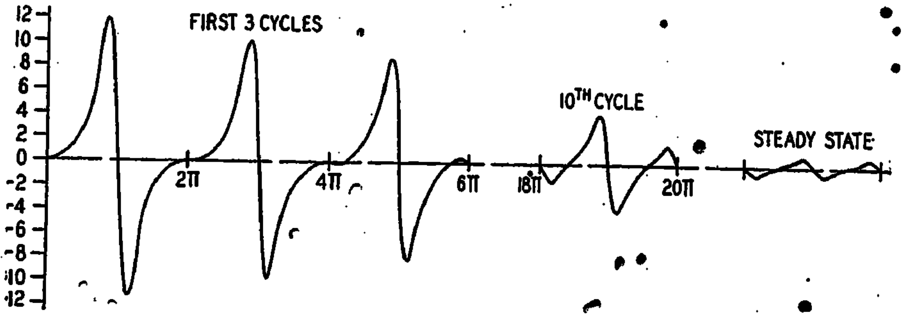

Fig. 1. Single-phase short-circuit torque of a 100,000-kva alternator, maximum initial armature linkages

$$\text{Torque} = -\frac{2F(F\cos t - A)\sin t}{H} - \frac{0.438(F\cos t - A)^2\sin 2t}{H^2}$$
$$= 5.25\,FA\,(\sin t + 0.669\sin 3t + 0.249\sin 5t + \ldots) -$$
$$(3.21\,F^2 + 1.92\,A^2)(\sin 2t + 0.446\sin 4t + 0.149\sin 6t + \ldots)$$
$$F = 0.449 + 0.417\epsilon^{-0.0021t} + 0.134\epsilon^{-0.060t}$$
$$A = \epsilon^{-0.025t}$$
$$H = 0.515 - 0.219\cos 2t$$

$$T = -\frac{2e_o^2F[F\cos(t+\alpha) - A]\sin(t+\alpha)}{H} + \frac{2e_o^2(x_d'' - x_q'')[F\cos(t+\alpha) - A]^2\sin 2(t+\alpha)}{H^2} \tag{5}$$

For the case of zero initial armature linkages, $\alpha = \pi/2$ and the above expression reduces to

$$T = \frac{2e_o^2x_q''F^2\sin 2t}{H^2} \tag{6}$$

The torque, expressed as the sum of odd and even harmonic series, is

$$T = \frac{e_o^2}{x_2 + x_d''}\left\{2FA\sum_{n=1,3,\ldots} nb^{\frac{n-1}{2}}\sin n(t+\alpha) - \left[F^2\frac{x_2}{x_2+x_d''} + A^2\frac{x_2 - x_d''}{x_2}\right]\sum_{n=2,4,\ldots} nb^{\frac{n-2}{2}}\sin n(t+\alpha)\right. \tag{7}$$

## SUMMARY OF RESULTS

The per-unit single-phase short-circuit torque is

$$T = \frac{2FAe_o^2}{x_2 + x_d''}\{\sin(t+\alpha) + 3b\sin 3(t+\alpha) + 5b^2\sin 5(t+\alpha) + \ldots\} - \frac{e_o^2}{x_2+x_d''}\left[F^2\frac{x_2}{x_2+x_d''} + A^2\frac{x_2 - x_d''}{x_2}\right]\{2\sin 2(t+\alpha) + 4b\sin 4(t+\alpha) + 6b^2\sin 6(t+\alpha) + \ldots\} \tag{8}$$

From an inspection of this equation it appears that the odd harmonic components of torque are due to the interaction of rotor and armature magnetic fields and that these components disappear as the trapped armature linkages die out. For the case of a short circuit with zero initial armature linkages no odd harmonic torques are present.

A part of the even harmonic torque is proportional to the square of the armature linkages and this part disappears when the subtransient reactances in the direct and quadrature axes are equal. This may be considered as a "reluctance torque" due to the variation in the permeance which the rotor offers to the trapped armature flux. Likewise, the part of the torque which is proportional to the square of the rotor linkages is due to the variation in the permeance which the armature offers to the rotor flux.

It is interesting to note that immediately after a short circuit with maximum armature linkages, the maximum value of second harmonic torque due to the field linkages alone is $x_2/(x_2 + x_d'')$ times the maximum fundamental torque, while the maximum value of second harmonic torque due to armature linkages alone is $(x_2 - x_d'')/x_2$ times the maximum fundamental torque. The maximum value of total second harmonic torque just after a short circuit with maximum armature linkages is $(2x_q'' - x_d'')/(x_q'' + x_2)$ times the maximum value of fundamental torque. This ratio varies from 0.5 for $x_d'' = x_q''$ to 1.25 for $x_d'' = 0.2\, x_q''$. Thus the maximum values of fundamental and second harmonic torque are of comparable magnitude just after short circuit.

Since the armature linkages eventually disappear, the steady state torque is made up entirely of even harmonic components.

### EXAMPLE OF CALCULATIONS

To illustrate the use of the formulas developed, numerical results have been calculated for a 60-cycle testing generator rated at 100,000 kva. The per unit constants of the machine, as determined by test, are as follows:

$x_d = 0.615$; $x_d' = 0.207$; $x_d'' = 0.148$
$x_q = 0.412$; $x_q' = 0.412$; $x_q'' = 0.367$
$\sigma_a = 0.025$; $\sigma_f' = 0.0021$; $\sigma_f'' = 0.069$

($x_q$ = quadrature axis synchronous reactance; $x_q'$ = quadrature axis transient reactance)

Hence $x_2 = 0.233$; $b = 0.223$

Figs. 1 and 2 show the line-to-line short-circuit torque with maximum initial armature linkages and zero initial armature linkages, respectively, as computed from the formulas derived.

From the standpoint of mechanical design of the machine and its foundations, the condition which gives maximum torque is the most important. It is evident that for this purpose it is sufficient to consider the torque with maximum initial armature linkages. In the case of the machine considered, the peak value of torque under this condition is nearly 12 times full load torque. It is to be noted that this high peak value is largely due to the presence of trapped armature linkages, since with no armature linkages the peak value of torque is only 4 times normal.

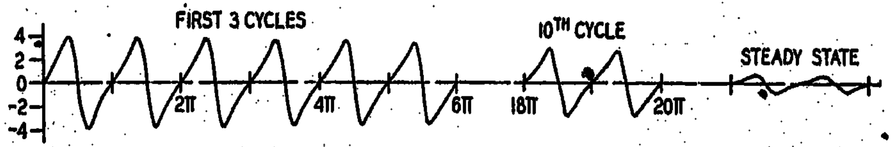

**Fig. 2. Single-phase short-circuit torque of a 100,000-kva alternator, zero initial armature linkages**

$$\text{Torque} = \frac{0.734\, F^2 \sin 2t}{H^2}$$

$$= 3.21\, F^2 (\sin 2t - 0.446 \sin 4t + 0.149 \sin 6t - \ldots)$$

$$F = 0.449 + 0.417\epsilon^{-0.0021\,t} + 0.134\epsilon^{-0.069\,t}$$

$$H = 0.515 + 0.219 \cos 2t$$

The trapped armature linkages are also responsible for all odd harmonic components of torque. Fig. 2 shows that with no trapped armature linkages the torque is made up entirely of even harmonics and in Fig. 1 it is seen that the odd harmonics decay gradually so that the torque curve approaches that of Fig. 2.

It appears from the eqs 5, 6, and 7 that the short circuit torque is the same for line-to-line and line-to-neutral short circuits. This is exactly true for an ideal machine and is true for actual machines provided that $x_0/2$ is negligible in comparison with $x_d''$ and $x_q''$ ($x_0$ = zero sequence reactance). Although the armature currents resulting from the two types of short circuit of an ideal machine are different, the armature mmfs are the same.

The consideration of machine losses would somewhat modify the torque as calculated in this article. The correction for losses can be calculated approximately in a given case, but this correction is generally small enough to be neglected.

# Motorized Pumps for Fuel Oil Trucks

INCREASING popularity of modern oil burners for heating purposes has resulted in a greatly increasing demand for fuel oil. Distribution of oil suitable for heating always has been a perplexing problem for this heavy oil must be pumped from the delivery vehicle to the customer's tank, even though the tank is below the level of the vehicle.

The delivery problem has been somewhat simplified and the delivery time greatly reduced by the Suburban Fuel Oil Service, Inc., Mount Vernon, N. Y., by replacing the mechanical pump drive with an electrical drive on one of its trucks, a 21-ton 6-wheel tractor-trailer type with a capacity of 3,000 gal. Originally the centrifugal pump with which this truck was equipped was mounted on the tractor; it was connected directly to a 4-speed power take-off on the transmission of the truck. In making a delivery 2 hoses had to be connected necessitating 4 hose connections in all.

In making the change to electrical drive, the pump was removed from the tractor and placed next to the tank on the left underside and is now driven through a silent chain drive by a 3-hp shunt motor. On the tractor the power take-off shaft was extended and, by means of a heavy duty silent chain, now drives a 3-hp

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Prepared especially for ELECTRICAL ENGINEERING from information contributed by Mark W. Copeland (M'31) consulting engineer, Westchester Sign Display Company, Bronx, N. Y.

shunt generator. A small $1/4$-hp compound-wound generator mounted near the main generator and driven by the power take-off shaft with a V belt, supplies constant field current to the motor and, through a specially designed rheostat, supplies variable field current to the generator. This rheostat provides the only control necessary both to start and stop the motor, and to vary the pump speed from about 15 to 375 rpm, its maximum rated speed. For the "off" position this rheostat circuit is simply opened, the armatures of the motor and generator being solidly connected together through a circuit breaker. With this arrangement but small currents, rarely exceeding 1 amp at 220 volts, are handled in the control circuit. Meters are provided to indicate directly (1) load in per cent of motor capacity, (2) pumping rate in gallons per minute, and (3) generator speed; the meter dials are illuminated for night operation.

Curves in Fig. 2 show delivery time before and after the pump was equipped for electrical operation; these are on the basis of 3,000-gal loads, with the number of deliveries per load plotted against time required for making hose connections and for pumping. In addition to the reduction in delivery time, the number of hose connections per delivery has been reduced from 4 to 1, the only connection necessary being that to the customer's tank. The truck has been in operation 24 hr per day for the past 8 months, without one failure. It is said to be the first and only truck equipped for pumping oil by this method.

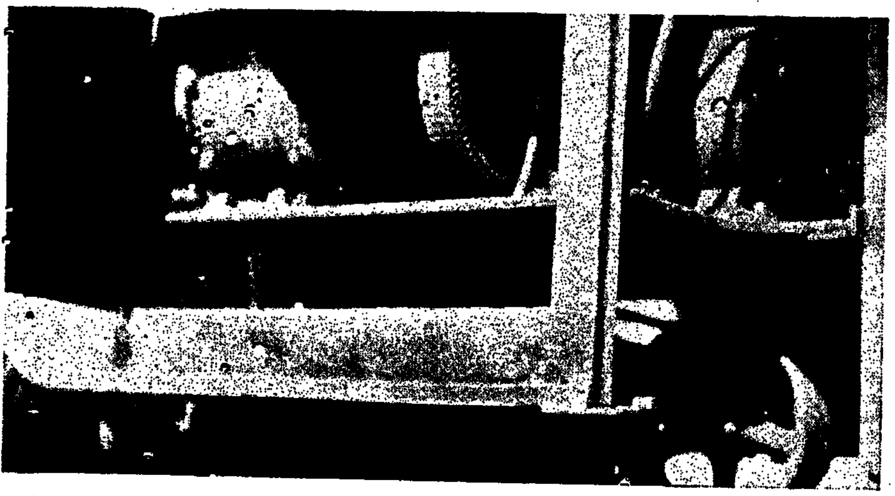

Fig. 1. View of electrically driven pump showing method of mounting

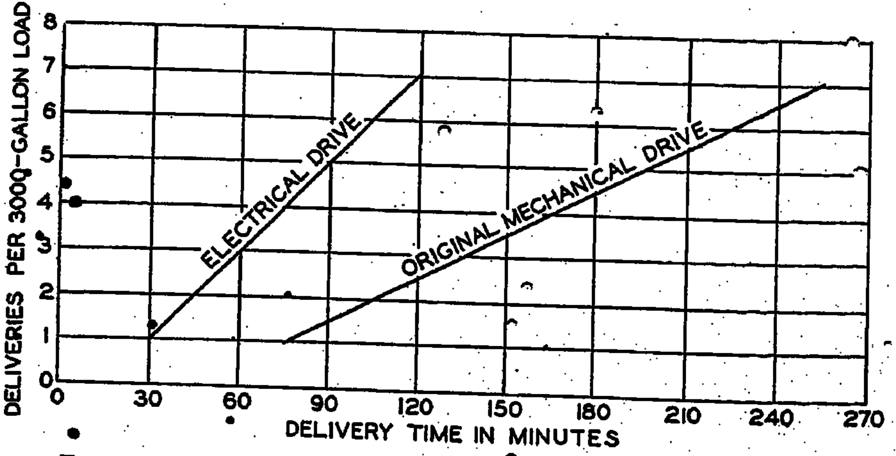

Fig. 2. Oil delivery time (No. 3 oil) before and after pump was equipped for electrical operation

Maximum pumping rate with original drive, 70 gpm; with electrical drive, 200 gpm

# Transformers With Peaked Waves

**Special purpose transformers now can be built to provide a secondary voltage wave less than 2 electrical degrees wide from a sinusoidal primary voltage source. The construction of such a transformer and some of its uses are described in this article.**

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ONE OF THE MOST RECENT developments in transformer design is that of a transformer with an extremely narrow secondary voltage wave. A peaked secondary voltage wave transformer may be defined as a transformer providing a narrow secondary voltage wave from a sinusoidal primary voltage source. The minimum width of wave thus far obtained is between 1 and 2 electrical degrees measured at $1/2$ of the maximum amplitude. However, the transformer can be designed for almost any width of wave above this value up to a limit of approximately 90 electrical degrees. These transformers have been produced during the last few years and are now available for commercial application.

Transformers of this type originally were designed and developed for stroboscopes in 1927 by C. A. Nickle (General Electric Company, Schenectady, N. Y.); in 1928 they were applied to thyratron (a grid controlled mercury vapor tube) inverter circuits. Since that time these transformers have been found to serve very well as component parts of frequency meters and tachometers.

Design of these transformers is somewhat different from that for other transformers. One of the vexing problems during the past with saturated type transformers has been the inherently high primary burden required from the supply source. This has been partially overcome by the present method of construction and the selection of material.

It is quite possible to obtain the required secondary voltage by using different methods of construction, but the most desirable method from the manufacturing point of view is that shown by Fig. 1. Before proceeding with the details of construction and operation, however, an explanation should be made of the fundamental object in the design. It is desired to

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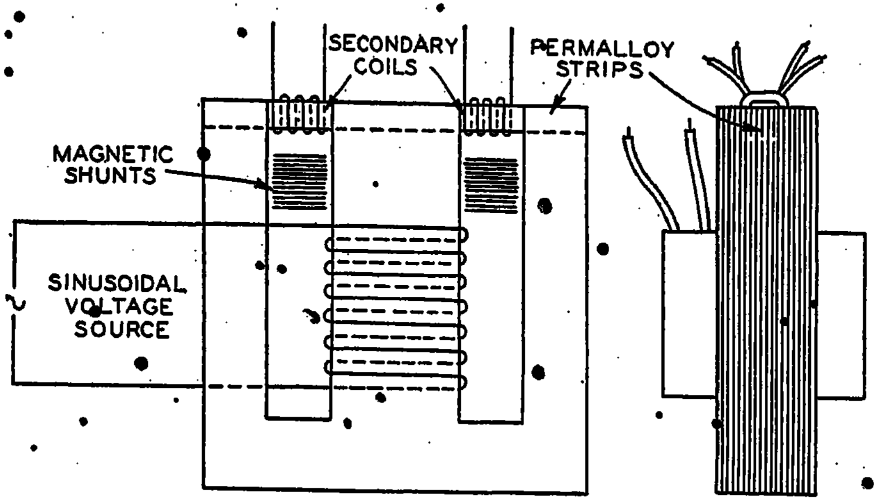


Fig. 1. Construction details of a transformer for peaked secondary voltage waves

saturate the secondary core section to a certain degree depending upon the required width of secondary voltage wave. With this condition the core section for the primary winding should not be saturated. To produce the peaked secondary voltage the secondary core material must possess a very steep magnetization curve below the knee, and beyond the knee it should be as nearly a horizontal line as possible. Permalloy (an alloy of nickel and iron) properly heat treated satisfies these requirements best.

In the type of construction shown in Fig. 1, the main core is comprised of the economical type of "E" punchings; these punchings are made from regular silicon steel, a material which can be operated at a flux density just below saturation. The primary coil is assembled onto the center leg of the core. Laminated magnetic shunts of the proper cross-section and length to permit a low reluctance are placed in each "window" between the primary and secondary coils. It is necessary that these shunts be of proper dimensions so that they will pass all of the flux not forced through the permalloy secondary core section for reasons explained later. In attempting to obtain the narrowest waves, permalloy strips 0.014 in. thick originally were used; these were placed across the open end of the "E" punchings. Later it was found that for a given cross-section of permalloy 0.0045-in. laminations produced a narrower wave than laminations of 0.014-in. thickness. However, unless an extremely narrow wave is essential the 0.0045-in. material should not be used, because of its more delicate and expensive character.

By making its cross-sectional area much less than that of the silicon steel, the permalloy core section must become saturated very quickly, providing the silicon steel section is operating at a density just below the knee of its magnetization curve. Since the magnetization curve for permalloy is quite flat after saturation is reached it is possible to keep the zero portion of the secondary voltage to a straight line. This portion of the wave must be held to zero throughout the entire period of time between alternate secondary peak waves, in order to meet the requirements of certain practical applications of the transformer.

From Fig. 2 it can be seen that the width of the secondary voltage wave is dependent upon the extent of magnetization of the permalloy core section or upon the amplitude of the secondary flux wave $\Phi_{sec}$. During the saturated period there is no change of flux; consequently, the secondary voltage must be 0 during that period. The flux changes rapidly from the positive saturated condition to the negative saturated condition producing a peaked voltage wave, which is equal in width to the angle $\theta$. If the air-gap be too large or the secondary coil build too high, there will be a fringing of flux through the coil; this flux cannot pass through the permalloy because of its saturated condition. As a result the peaked voltage will contain a superimposed sine wave component voltage, the amplitude of which possibily could be a considerable fraction of the maximum amplitude of the peaked voltage wave. Obviously, it is advisable to avoid this component.

Extremely narrow waves could be obtained more easily by using a primary flux wave having a flat top and very steep sides; this is because the flux changes more rapidly in a wave of that sort than in a sine wave. Such a flux wave could be obtained by using an additional transformer between the source of supply and the peaked voltage transformer.

Wave shapes of the peaked voltage transformers have decidedly good features such as steep sides, flat top, and a straight line zero portion. As one might expect, they do not take the shape of a "saw tooth" or of a wave having a form factor of approximately 1.6. The true shape can be seen from Fig. 2, and from actual oscillograms reproduced in Fig. 3. Variations in the supply voltage alter the width of the wave but slightly.

The burden taken by a transformer having a 2° wave required only 0.15 amp exciting current and 1.5 watts at 110 volts and 60 cycles; if necessary, even this small burden can be reduced. Characteristic curves for a typical transformer under different conditions are shown in Fig. 4.

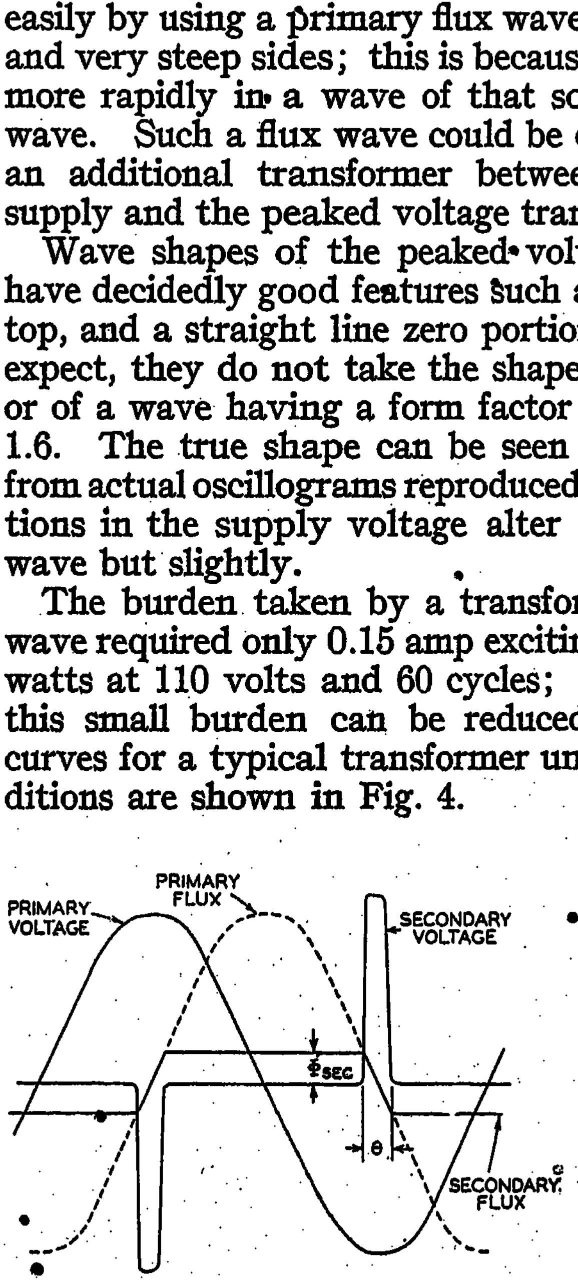
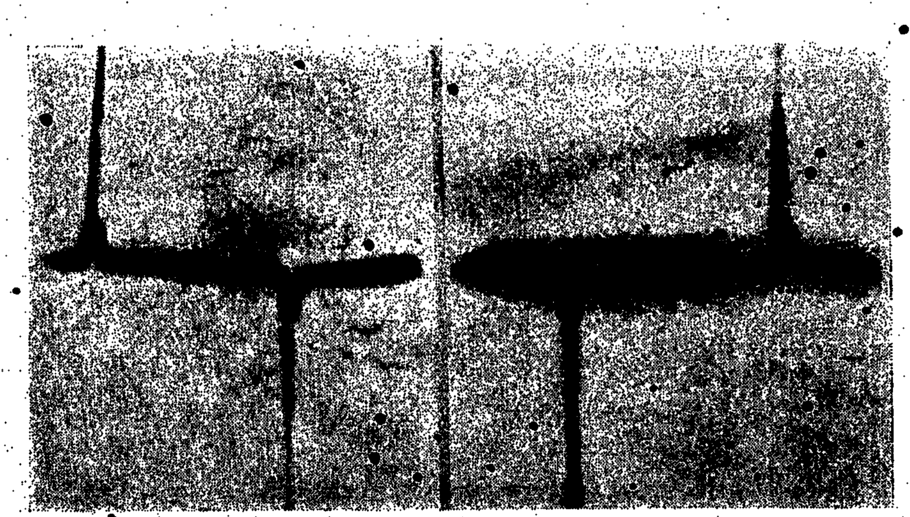


Fig. 2. Voltage relations in the peaked-voltage transformer

Fig. 3. (Below) Oscillograms of the transformer secondary voltage



100-volt 60-cycle waves approximately 3° wide (left) and 10° wide (right) at half maximum amplitude

Recognition should be given to B. D. Bedford (General Electric Company, Schenectady, N. Y.) for his original work on this type of transformer and for his valuable suggestions during the development.

## Uses for the Peaked Voltage Transformer

As mentioned previously, one of the earliest applications of the peaked secondary voltage wave transformer was in inverter circuits using the grid-controlled mercury vapor tube. A peak voltage is essential for excitation circuits of this tube for several reasons:

1. In certain circuits peaked excitation causes the phase position of the initial excitation to be independent of the time the switch is closed.

2. In many tube circuits the excitation period must be short. For example, in inverter circuits the excitation period of a tube should be at least as short as its conducting period.

3. A very steep wave front for grid excitation has the advantage over other wave forms since any change in grid potential or tube characteristics will have small effect on the time of excitation.

4. In frequency changers using this tube the low frequency excitation may be used to turn on and off the high frequency excitation by means of a transformer with a peaked secondary voltage wave.

Since many new circuits for the grid controlled mercury vapor tube are being developed continually, it is thought that this type of transformer will be used extensively in this field because it can serve as an essential component part in many of the circuits.

A combined transformer with peaked secondary voltage and neon lamp furnish the essential component parts of a good stroboscope. If the viewing is done through a narrow slot in the stroboscope disk, the width of the light spot on the disk will be dependent upon the width of the secondary voltage wave from the supply transformer. The spot will be very narrow with the use of a 5° voltage wave and also very sharp. Synchronous characteristics or the phase displacement between 2 voltage waves can be viewed readily and conveniently by this method.

It seems that there are many applications for a peaked voltage transformer with features for shifting the secondary voltage with respect to the primary voltage. This is especially desirable for certain tube applications such as frequency converters using the grid controlled mercury vapor tube, and polycyclic inverters. Several methods of obtaining the shifted peaked voltage have been used, but the following paragraphs illustrate one method which has been quite satisfactory.

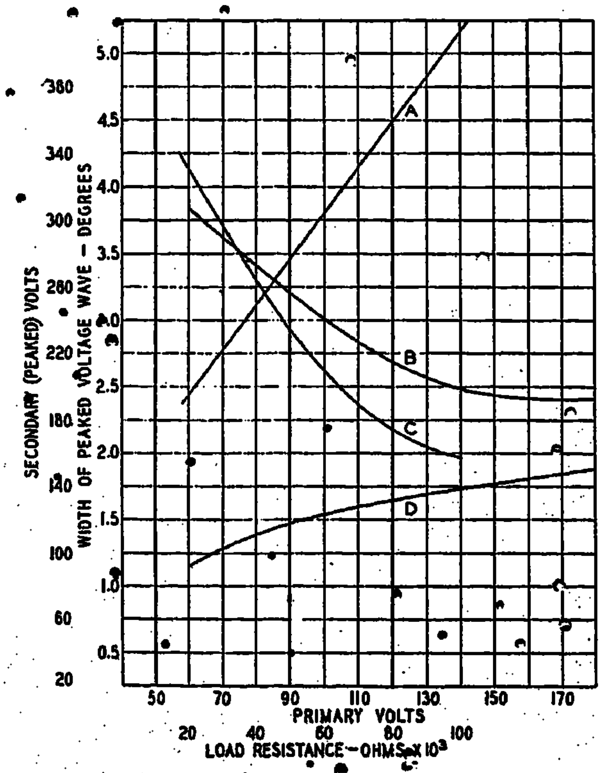


**Fig. 4. Characteristic curves for a typical transformer for peaked voltage**

A—Secondary peak volts vs primary volts
B—Width of wave vs load resistance
C—Width of wave vs primary volts
D—Secondary peak volts vs load resistance
Curves A, B, and C are for both secondary coils in series; Curve D is for one secondary coil with the other coil open (see Fig. 1)

Construction similar to that shown in Fig. 1 is used except that an auxiliary coil is added on the center leg of the core spaced between the magnetic shunts and 2 additional shunts placed next to the secondary coils, as shown in Fig. 5. It is possible to obtain shifts in one direction to a maximum of 135 electrical degrees. Several units were built having a 40-volt peaked wave with a width of approximately 4°, shifted only 90° away from the primary voltage instead of the usual 180°. Although a small shift can be obtained by connecting the auxiliary coil so that its mmf aids that of the main coil, the maximum shift is obtained by connecting this coil so that its mmf opposes that of the main coil, when both are connected to the same source of supply voltage. Some means of control must be used to vary the auxiliary coil mmf so that the desired variation in the angle of shift can be obtained. Best results are obtained by using a variable series resistor instead of an inductor or condenser to vary the amount of current in the auxiliary coil. It can be seen that the change of resistance in the one circuit varies the voltage across the auxiliary coil, and this is accompanied by a change of the magnetizing current in the primary coil. Such a combination causes the mmf's of the 2 coils to be out of phase with each other and to produce a fundamental mmf out of phase with the primary voltage. The permalloy section of the core of course conducts only the displaced flux and consequently the peaked secondary voltage is displaced accordingly from the primary voltage.

The burden required for such a device is not excessive. Those units of this type to which reference was just made required only 13.5 va at 90 volts and 50 cycles. With increases in phase shift the burden is increased, but it is quite probable that for most purposes a shift greater than 90° is not necessary. Amplitude, width of wave, and phase displacement of the peaked secondary voltage waves are not changed appreciably by large variations of the primary voltage.

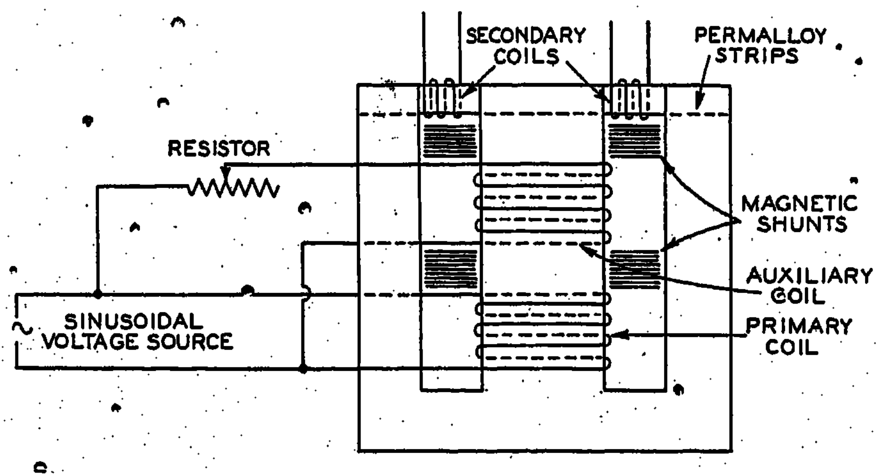


**Fig. 5. Construction of peaked-voltage transformer with provisions for shifting the phase relations of the secondary and primary voltages**

# Cables, Water Power, Dominate Baltimore Sessions

OF THE 4 regular sessions of the Middle Eastern District meeting held Oct. 10–13, 1932, at the Lord Baltimore Hotel in Baltimore, Md., one was given over to 4 papers dealing with power cables, one to 3 papers concerned with communication cables, and 2 to the presentation of 6 papers devoted to hydroelectric subjects including delivery and distribution of power so generated. Meeting jointly with the Institute for the first 2 (cable) sessions, was the National Research Council's committee on electrical insulation which functions under the leadership of Dr. J. B. Whitehead. This latter committee subsequently held 3 independent sessions in Maryland Hall on the Johns Hopkins campus, but otherwise participated in the general activities of the meeting. The Institute's board of directors also met in conjunction with the meeting, as reported elsewhere in this issue.

Analysis of Attendance at Baltimore

| Classification | Baltimore | Dist. No. 2 | Dist. No. 3 | Dist. No. 1 | Misc. | Totals |
|---|---|---|---|---|---|---|
| Members | 76 | 50 | 33 | 18 | 18 | 195 |
| Men Guests | 13 | 13 | 1 | 2 | 4 | 33 |
| Women Guests | 6 | 2 | 3 | 1 | 0 | 12 |
| Totals | 95 | 65 | 37 | 21 | 22 | 240 |

Registration totaled 240, classified as indicated in the accompanying tabulation, a turn-out that paid tribute to the general interest value of the technical program presented by the Baltimore meeting committee. Further response to the program's appeal was evidenced by the attendance at the individual sessions, ranging from 125 to 180, and by the discussions, which were distinctly above the average in quality and in quantity. The various activities which were coordinated during the 3 days of the meeting evidently exerted a favorable influence upon the attendance from points relatively remote from Baltimore.

### Technical Sessions

Allowing Monday morning, for the convenience of late arrivals, for registration, and for a District executive committee meeting (reported elsewhere in this issue) the technical sessions were held Monday afternoon, Tuesday morning, and Wednesday morning and afternoon as outlined in the program published on p. 664 of Electrical Engineering for Sept. 1932. Presiding at these sessions were, respectively, Dr. J. B. Whitehead, dean of engineering at The Johns Hopkins University, Baltimore, Md.; J. L. D. Speer, Jr., chief engineer, Chesapeake & Potomac Telephone Company of Baltimore City, Md.; A. F. Bang, superintendent of operation, Pennsylvania Water & Power Company, Baltimore, Md.; and J. R. Baker, operating engineer, Pennsylvania Water & Power Company, Baltimore, Md.

Organized inspection trips provided for visits to points of timely interest in the vicinity of Baltimore. On Monday evening a group visited the plant of the Locke Insulator Company where, after a brief turn of inspection through the factory, a demonstration of an interesting and spectacular nature was staged in the company's 3,000,000-volt laboratory. One of the Tuesday afternoon trips included visits to 2 local steam-electric generating plants and to the Baltimore terminal substation of the Safe Harbor 230-kv transmission system. As an alternate to this trip, others visited the Western Electric Company's insulated wire mill and cable plant and the nearby factory of the General Aviation Company. All day Thursday was given over to a trip to the Safe Harbor hydroelectric plant of the Pennsylvania Water & Power Company. A special car was handled on regular Pennsylvania trains between Baltimore and Perryville, Pa., then to and from the plant by a special locomotive. Ample time was available for a thorough inspection of the plant and all of its associated structures. Luncheon was served at the plant by the power company.

### Entertainment

Entertainment features provided were simple in character, but nicely rounded out the meeting program. Women guests were taken Tuesday afternoon to the United States Naval Academy at Annapolis where they were shown the sights and subsequently served with tea at Carvel Hall. An informal sight-seeing trip and tea also were provided for the women Wednesday afternoon.

At an informal gathering Tuesday evening, with Dr. W. B. Kouwenhoven, A.I.E.E. vice-president for the Middle Eastern District, presiding, President Charlesworth presented certificates and prizes to W. P. Taylor of Baltimore who won both the initial-paper prize and the best-paper prize for his District for 1931 as reported on p. 418 of Electrical Engineering for June 1932. Subsequently called upon to address the gathering, President Charlesworth gave public recognition of the work done by the personnel of the local meeting committees, and spoke briefly upon Institute affairs in general. He called attention to the fact that the Institute for more than 48 years has devoted its efforts to the furtherance of the ideal laid down by its founders in 1884: "the advancement of the theory and practice of electrical engineering and of the allied arts and sciences, the maintenance of a high professional standing among its members, and development of the individual engineer." President Charlesworth also outlined briefly the various successive steps in broadening the Institute's services to its members—through the formation and development of local Sections and subsequently of Student Branches, and in recent years the extension of regional activities including District conventions. Current problems came up for brief mention, too, as he cited the efforts of the finance committee and the headquarters staff in attempting to meet the rigorous requirements of a substantially reduced budget without impairment to the Institute's more important services to its members. President Charlesworth bespoke support and cooperation for the national officers and the office staff in their efforts to cope with the present situation. Following this, Dr. Adolph H. Shultz, associate professor of physical anthropology at The Johns Hopkins University, delivered an enlightening and challenging illustrated lecture, "Man as a Primate," in which he presented excerpts from a mass of data revealing close similarities between man and the higher forms of anthropoids, notably the orang-utan, the chimpanzee, and the gorilla.

Culminating the social activities of the Baltimore meeting was the dinner-dance held at the Lord Baltimore Hotel, Wednesday evening.

# November 15 Last Date for Suggesting Nominations

Actions specified in the Institute's constitution and by-laws relative to the organization of a national nominating committee are being taken, and the meeting of the national nominating committee for the nomination of officers to be voted upon at the election in the spring of 1933 will be held between November 15 and December 15, 1932. All suggestions for the consideration of the national nominating committee must be received by the secretary of the committee at Institute headquarters, New York, N. Y., not later than November 15, 1932.

## A.I.E.E. Directors Meet at Baltimore

A regular meeting of the board of directors of the American Institute of Electrical Engineers was held at the Lord Baltimore Hotel, Baltimore, Md., on Wednesday, October 12, 1932, during the Institute's Middle Eastern District meeting.

Present were: *President*—H. P. Charlesworth, New York, N. Y.; *Past-presidents*—W. S. Lee, Charlotte, N. C.; C. E. Skinner, East Pittsburgh, Pa.; *Vice-presidents*—W. W. Freeman, Lexington, Ky.; J. Allen Johnson, Buffalo, N. Y.; W. B. Kouwenhoven, Baltimore, Md.; P. H. Patton, Omaha, Neb.; *Directors*—L. W. Chubb, East Pittsburgh, Pa.; A. B. Cooper, Toronto, Ont.; B. D. Hull, Dallas, Tex.; A. E. Knowlton, New York, N. Y.; G. A. Kositzky, Cleveland, Ohio; A. H. Lovell, Ann Arbor, Mich.; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New York, N. Y.; A. C. Stevens, Schenectady, N. Y.; H. R. Woodrow, Brooklyn, N. Y.; *National treasurer*—W. I. Slichter, New York, N. Y.; *Acting national secretary*—H. H. Henline, New York, N. Y.

The minutes of the board's meeting held August 2, 1932, were approved.

A memorial resolution was adopted in memory of Dr. C. O. Mailloux, a charter member and past-president of the Institute, who died on October 4, 1932. This resolution is published elsewhere in this issue.

A report of a meeting of the board of examiners held September 28, 1932, was presented and approved. Upon the recommendation of the board of examiners, the following actions were taken upon pending applications: 6 applicants were transferred to the grade of Fellow; 6 applicants were elected and 30 were transferred to the grade of Member; 38 applicants were elected to the grade of Associate; 138 Students were enrolled.

The following resolution was adopted:

> WHEREAS, death has suddenly removed Colonel Basil C. Battye, D.S.O., A.M., Local Honorary Secretary for India of the American Institute of Electrical Engineers, be it
>
> RESOLVED: That the board of directors at its meeting of October 12, 1932, places this minute on record as an appreciation of the loyal and devoted service which Colonel Battye gave to the Institute as its official representative in India. His thorough understanding of conditions in India, and his able judgment have served as an unfailing guide to our board of examiners through many otherwise perplexing problems.

The resignation of George A. Mills as a vice-president of the Institute, representing the South West District, on account of his removal from that District, was presented; and Stanley Stokes, consulting electrical engineer of the Union Electric Light and Power Company, St. Louis, Mo., and a Fellow of the Institute, was elected vice-president of the Institute for Mr. Mills' unexpired term, ending July 31, 1934.

The following members of the Board of Directors were selected to serve on the national nominating committee for this year: A. B. Cooper, A. E. Knowlton, W. S. Lee, A. C. Stevens, and H. R. Woodrow.

The Institute's representative upon the joint committee of engineers and architects was discharged, report having been made of the completion of the committee's work.

A report was received from Chairman F. B. Jewett of the Institute's committee on Iwadare Foundation, to the effect that the committee had arranged for Dr. Frank J. Sprague, a past-president of the A.I.E.E., to lecture in Japan this fall under the Iwadare Foundation.

Institute representatives were appointed as follows:

**On Standards Council, American Standards Association.**—A. M. MacCutcheon was reappointed a representative for the 3-year term beginning January 1, 1933, and H. H. Henline and E. B. Paxton were reappointed alternate representatives for the calendar year 1933. H. S. Osborne was designated as the chairman of the Institute's representation on the standards council.

**On Engineering Foundation Board.**—Past-president C. E. Skinner was reappointed for the 3-year term beginning in February 1933.

**On Library Board, United Engineering Trustees, Inc.**—W. A. Del Mar was reappointed for the 4-year term beginning in January 1933.

**On Board of Trustees, United Engineering Trustees, Inc.**—President H. P. Charlesworth was reappointed for the 3-year term beginning in January 1933.

The following actions were taken upon the recommendation of the standards committee:

Approved a revision of Section 4-102 of A.I.E.E. Standard No. 4, "Measurement of Test Voltages in Dielectric Tests," as suggested by the committee on electrical machinery.

Approved a revision, proposed by the committee on electrical machinery, of A.I.E.E. Standard No. 13 on "Transformers, Induction Regulators, and Reactors," and referred it to the sectional committee on transformers being organized under the sponsorship of the electrical standards committee of the American Standards Association.

Adopted a recommendation in favor of a proposed revision of the present A.I.E.E. Standard No. 14, "Instrument Transformers," for reference to the sectional committee on electrical measuring instruments which is being organized under the sponsorship of the electrical standards committee of the A.S.A.

Approved, as a joint sponsor, the revised "Code for Protection Against Lightning" as prepared by the sectional committee on that subject.

Granted permission to the U.S. Department of Commerce to publish the A.I.E.E. standards in the *Encyclopedia for Standards and Specifications.*

Granted permission to the Asociacion de Ingenieros del I.C.A.I. to reprint the Institute standards in the Spanish language.

A resolution was adopted decreasing the number of meetings of the board of directors during the year beginning October 1, 1932, in order to reduce expenditures for traveling expenses; meetings of the executive committee to be substituted at the discretion of the president. In line with this action

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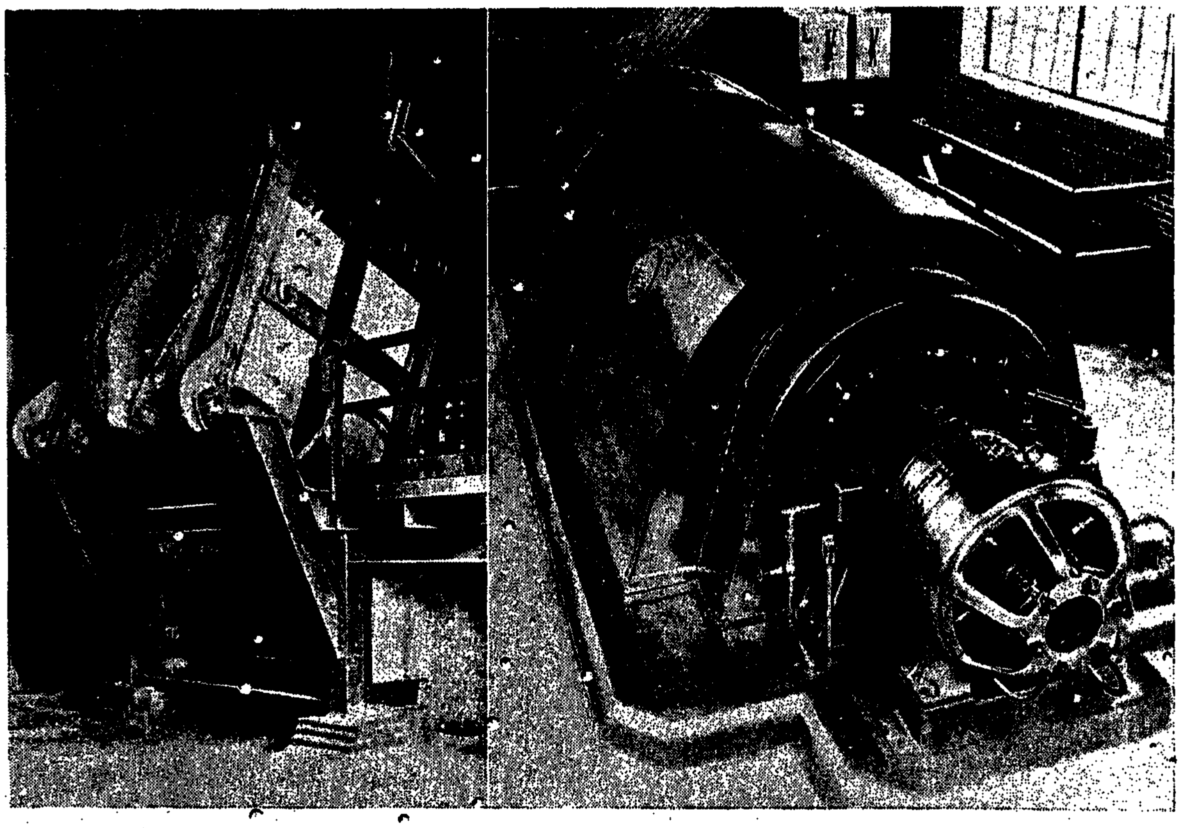
## A 4-Ton Coreless Induction Furnace



During the fall of 1931 a 4-ton coreless furnace capable of melting 40 to 50 tons per day was put in operation in the Chicago district. This is almost double the size of any coreless melting furnace previously installed. The main purpose of the furnace is to melt low carbon stainless steep scrap, also ferro-alloys for addition to larger furnaces, and metal for ingots of high quality tool steel and other alloys. The coreless induction furnace is essentially an air transformer whose primary is a single helical layer of water cooled copper tubing, and whose secondary within the coil is a conducting mass constituting the charge to be melted. Induced currents circulate in the outer part of the charge, and thereby heat it. The furnace, tilted for pouring, is illustrated on the left, and the 1,000-cycle motor generator set is shown on the right. The use of structural steel in the construction of the furnace is more extensive than in any previous installation. Another distinguishing feature of this installation is the carrying of 12,000 amp at 1,000 cycles by means of water cooled tubing interlaced to cut down inductance.

it was voted that the December meeting of the board be omitted and that the next meeting be held in New York, in January, during the Institute's winter convention.

Also because of economic conditions, the board voted to omit the publication of a YEAR BOOK in 1933 and to omit the cash prizes for papers presented in the calendar year 1932, except the District prizes for Branch papers; the certificates for all prizes to be issued as usual.

A budget for the appropriation year of the Institute beginning October 1, 1932, submitted by the finance committee, was adopted with minor revisions.

The board adopted a resolution of congratulation to the local meeting committees upon the excellent results of their efforts in connection with the Middle Eastern District meeting of the Institute, held at Baltimore, October 10–13.

Other subjects were discussed, reference to which may be found in this or future issues of ELECTRICAL ENGINEERING.

## District No. 2 Officers Meet at Baltimore

Preceding the first technical session of the Middle Eastern District meeting held at Baltimore, October 10–13, 1932, the executive committee of that district met Monday morning, October 10, with Dr. W. B. Kouwenhoven, district vice-president, presiding. Every one of the 12 sections in the district was represented and the attendance was full, as indicated in the accompanying tabulation, with the exception of the Student Branch counselor member. Extensive routine District business and discussions of matters of policy kept the committee in session all morning, after which the committee adjourned to an informal luncheon from which they went directly to the opening technical session. Present were:

H. P. Charlesworth, President, A.I.E.E. (visitor)
W. B. Kouwenhoven, Vice-president, District No. 2
Geo. S. Diehl, Secretary, District No. 2
H. H. Henline, Acting Nat. Secy., A.I.E.E.
C. E. Skinner, Past-president, A.I.E.E. (visitor)
A. P. Regal, Section Chairman, Akron, Ohio
John Wells, Section Chairman, Baltimore, Md.
L. O. Dorfman, Section Chairman, Cincinnati, Ohio
John M. Smith, Section Chairman, Cleveland, Ohio
W. L. Everitt, Section Delegate, Columbus, Ohio
C. V. Roberts, Section Secretary, Erie, Pa.
N. S. Hibshman, Section Delegate, Lehigh Valley
J. L. MacBurney, Section Secy., Philadelphia, Pa.
Thomas Spooner, Sec. Chairman, Pittsburgh, Pa.
A. P. Bender, Section Chairman, Sharon, Pa.
I. H. Heitkamp, Section Chairman, Toledo, Ohio
T. J. MacKavanagh, Sec. Chmn., Washington

In accordance with the requirement in article VI of the constitution, Prof. A. M. Wilson (A'09–M'18) professor of electrical engineering at the University of Cincinnati (Ohio) was nominated for the office of vice-president of the Institute representing District No. 2 for the 2-year term beginning August 1, 1933. To represent District No. 2 on the national nominating committee, which probably will hold its meeting some time early in December, John Wells (A'27) development engineer for the Western Electric Company, Baltimore, and chairman of the Baltimore Section (1932–33) was appointed and given instructions.

To form, in accordance with section 33 of the by-laws, "A small continuously functioning coordinating committee" Thomas Spooner (F'29) of Pittsburgh, John M. Smith (A'24) of Cleveland, L. O. Dorfman (M'28) of Cincinnati, and T. J. MacKavanagh (M'13) of Washington, D. C., were appointed from the executive committee and Prof. Lewis Fussell (M'22) Professor of electrical engineering of Swarthmore, (Pa.) College representing the student branch counselors, were elected to serve with the district vice-president and secretary.

To serve District No. 2 for the year 1932–33 a District prize award committee was appointed, consisting of Dr. H. L. Curtis (A'21–F'26) Washington, D. C., A. P. Bender (A'18) Sharon, Pa., and Prof. S. S. Seyfert (M'13) Lehigh University, Bethlehem, Pa. Dr. Curtis will serve as chairman of this committee.

Concerning future district meetings for the Middle Eastern District, and their financing, there was considerable discussion. Concerning the matter of finance, the concensus of opinion was to the effect that all sections in the district should bear a reasonably proportionate share of the expense of holding each district meeting, regardless of where it may be held; the group decided to continue the present plan of requesting each section to pay an assessment of $10 plus 10 cents per member in that section as of August 1. The question of a meeting for 1934 was discussed, but no requests for such meeting were voiced and no recommendations were made.

## Winter Convention Committee Appointed

The general convention committee in charge of arrangements for the coming annual winter convention of the Institute which is to be held in the Engineering Societies Building, New York, N. Y., January 23–27, 1933, has been appointed by President Charlesworth. Plans for the various events which are to comprise this convention are assuming definite form, a tentative program of technical sessions has been made, and the preparation of papers for these sessions is well under way.

As members of the general convention committee President Charlesworth has appointed the following: *chairman*, E. B. Meyer (F'27) vice-president District 3; J. W. Barker (F'30) member, technical program committee; T. F. Barton (F'30) chairman, New York Section; F. M. Farmer (F'13) member, research, and power transmission and distribution committees; W. H. Harrison (F'31) chairman, technical program committee; L. W. W. Morrow (F'25) Institute representative on Engineers' Council for Professional Development; C. E. Stephens (M'22) director, and chairman, finance committee; H. R. Woodrow (F'23) director, and C. R. Jones (A'16,M'30) secretary District 3.

Ample material is available for the technical sessions, and these include a wide range of subjects in the field of electrical engineering. Special plans are being made for the communication session and these tentatively provide for the presentation of 5 papers on the communication system of railroads. Tentative plans of the committee on education provide for a symposium on post college education. The electrical machinery committee also is making special plans, and these include the holding of an informal session on noise. At some other sessions presentation of manuscripts without publication and without distribution of advance copies is being considered.

Subjects tentatively under consideration for technical sessions are: communication, electric welding, automatic stations, electrical machinery, transportation, education, industrial applications, lightning, electrochemistry and electrometallurgy, instruments and measurements, applications to mining work, protective devices, selected subjects and, research and applied electronics. Detailed plans for the technical sessions, social features, and inspection trips will be announced in future issues of ELECTRICAL ENGINEERING.

## Generation Committee Plans New Papers

Capitalizing upon the opportunity presented by the recent Middle Eastern District Meeting held at Baltimore, Md., October 10–13, 1932, Chairman J. R. Baker called a meeting of his committee on power generation on October 12.

To orient the committee, the activities during the past 4 years were reviewed and the papers produced on the general subject of electric power generation were listed in 3 groups according to classification of subject matter: (1) steam-electric production, (2) hydroelectric production, and (3) utilization of sources of power supply by means of interconnection. According to their types these papers were segregated further into such classifications as plant descriptions, analytical discussions, and reports of experimental work. There have been 23 papers on the subject of steam-electric generating plants, 16 concerning hydroelectric practise, and 18 dealing with various phases of interconnection.

Of the 3 subjects mentioned in the foregoing paragraphs 2 were considered to have been fully reported upon to date and to have been adequately described and analyzed for the present: developments in hydroelectric practise, and matters pertaining to interconnection. Recent progress in the field of steam-electric power production was considered to be of timely importance and to be a desirable subject for a paper to be presented in the near future, so as to call attention to profitable lines of design. Possible sources of such a paper were discussed; 2 plants now under construction were considered as exemplifying present trends, one in initial design and the other as a splendid example of rehabilitation.

Electrical testing of welded pressure vessels came up for consideration and specifications were discussed for a suitable paper relating to that subject that might be presented in conjunction with one already on hand concerning the economics of high pressure and high temperature. The committee gave attention to the difficulty of giving a complete understanding of advances in power generation without elaborating too deeply upon the features of mechanical design. Plans also were made for a paper that would describe the electrical system adopted in a large plant recently placed in operation in which both a 60-cycle and a 25-cycle electric power supply were demanded. Other subjects to be initiated will concern safety devices in electrical operation, automatic turbine control through remote metering, and power control at generating stations. A subcommittee was established to handle a contemplated progress report covering the present biennial period.

## Birmingham Section Reorganization Announced

A meeting of the Birmingham Section of the Institute was held on September 30, 1932, for the purpose of discussing future plans and reorganizing the Section. The meeting took place in the Tutwiler Hotel, the reported attendance being 17 Institute members and 1 Student member. F. C. Weiss (M'19) acted as presiding officer.

Following a discussion of various schemes to best serve the Birmingham Section, an organization was formed to carry on the Section's business and maintain a nucleus around which additional activities can be added as the occasions demand. The new chairman is Howard Duryea (A'11) Commonwealth & Southern Corporation, Birmingham, Ala., and the new secretary is H. M. Woodward (M'29) Southern Bell Tel. & Tel. Company, Birmingham, Ala. The following were named as the executive committee: Prof. F. R. Maxwell (M'30) University of Alabama, Tuscaloosa, Ala., Prof. W. W. Hill (M'24) Alabama Polytechnic Institute, Auburn, Ala., and W. W. Ballew (M'28) Westinghouse Elec. & Mfg. Co., Birmingham, Ala. With the organization of the Birmingham Section, the present list of Institute Sections is made complete.

## District No. 8 Officers Meet at San Francisco

With Pacific District Vice-President A. W. Copley in the chair, the executive committee of the Pacific District held its annual meeting at the Engineers' Club in San Francisco September 7, 1932. With the exception of A. P. Hill, secretary of the Los Angeles Section, all members were present; in addition to the chairman were:

C. E. Baugh, secretary, District No. 8.
F. E. Dellinger, chairman, Los Angeles Section.
E. F. Maryatt, chairman, San Francisco Section.
Roy Wilkins, secretary, San Francisco Section.
L. E. Reukema, chairman, District student activities.

As nominee for Institute's vice-president for the 2-year term August 1, 1933–July 31, 1935, representing District No. 8, Prof. R. W. Sorensen (A'07, F'19) professor of electrical engineering at California Institute of Technology, Pasadena, was selected by unanimous vote.

## A Review of Foreign Broadcasting Systems

Ten years ago, 6 British radio manufacturers contributed £10,000 each to a common fund with which to commence a system of domestic broadcasting in Great Britain. They formed the British Broadcasting Company, Ltd., which, for 4 years, pioneered broadcasting. In 1926, the company obtained a royal charter and became the British Broadcasting Corporation—known familiarly as the B.B.C.—licensed by the government to transmit broadcast material of every description with only one fundamental restriction: the B.B.C. cannot accept monetary considerations from outside interests in return for broadcasting programs. In other words, it cannot transmit advertising programs for payment; its revenue is derivable solely from a license fee paid by owners of receiving apparatus.

The broadcasting system of Great Britain is almost unique. It is controlled by a board of governors appointed by the government. It operates under a license granted by the postmaster-general, who charges every set-owner 10 shillings per annum for the right to install and operate a receiving station, or in other words, a radio set. From this 10-shilling fee the post office allots a proportion (about 48 per cent) to the B.B.C. as a contribution toward the expenses of broadcasting programs and another portion goes to the national exchequer. There is nothing to insure that the B.B.C. shall receive any contribution at all from the post office license revenue and if the present 48 per cent were stopped or reduced, the B.B.C. might be forced to accept "sponsored programs."

The B.B.C. is a semi-state department as its directorial personnel is appointed by the government and its revenue granted by the postmaster-general almost ex-gratia. Also, the government of the day has first call on any air time and has more than once exercised that right. The B.B.C., as a semi-state department can be criticized in parliament. No fundamental alteration in the constitution of the B.B.C. and the present policy of British broadcasting can be effected until 1937 when the charter expires and comes up for renewal or modification.

Broadcasting is vastly different both on the continent and in the United States, the latter being entirely on a commercial basis. Canada now has decided to remodel its broadcasting system from the American method of commercialization to the British method of centralized control directed to securing highest entertainment value. Government control is also effective in Czechoslovakia, when the Prague station broadcasts some of the most popular programs. Danish broadcasting is governed by the state radio council and financed by the proceeds from license fees.

France has its own method. While there is no monopoly as there is in Great Britain, the majority of the stations are owned by the government through the ministry of posts, telegraphs, and telephones. There are 28 broadcasting stations in that country. A license fee of one franc per year is charged French citizens while foreigners have to pay 10 francs per year.

A broadcasting monopoly is enjoyed by the postal service in Germany while broadcasting is prohibited in Greece, although the government is contemplating creating a monopoly. Monopolistic control is effective also in Hungary where radio is under the control of the postal administration and about 2s. 6d. per year is charged to receivers. Broadcasting is also a monopoly in the Irish Free State and 10s. license fee, as in Great Britain, is charged. Before the end of this year a new high-powered station will be opened in Ireland, whence "sponsored programs" will be transmitted.

The broadcasting situation in Holland is peculiar and almost resolves itself into a war between the non-partisan Association of Listeners, with about 100,000 paying members, the Socialist, and the Catholic broadcasting organizations. There are 2 Dutch stations—Hilversum and Huizen—but only one station can function at a time and the time allotted to each organization is computed upon the basis of the number of members belonging to each. The authority which decides all radio matters is the Radioraad which is presided over by a high government postal official.

—Excerpts from an article appearing in *Industrial Britain* for August 1932, p. 3.

## Noble Prize Awarded to Institute Member

The Alfred Noble Prize for 1932 is to be awarded to F. M. Starr (A'30) for his paper "Equivalent Circuits—I." This paper was presented at the A.I.E.E. winter convention, New York, N. Y., January 25–29, 1932, and was published in the A.I.E.E. TRANS., v. 51, 1932, p. 287–98. An article based upon this paper was published in ELECTRICAL ENGINEERING for August 1932, p. 555–8. An item regarding Mr. Starr is given in the personal columns of this issue.

This is the second award of the Alfred Noble Prize, the 1931 award having been made to Prof. C. T. Eddy of the Michigan College of Mining and Technology, Houghton, Mich. The prize was established in 1929 and at present consists of an award of $500 from the income of the fund contributed by engineers and others in honor of Alfred Noble, past-president of the American Society of Civil Engineers and of the Western Society of Engineers, and for the purpose of perpetuating his name and achievements. Alfred Noble, one of the most prominent civil engineers active during the 50 years preceding 1914, in addition to his technical achievements was greatly interested in the younger men of the engineering profession.

The award is made to a member of any grade of either the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, or the Western Society of Engineers, for a technical paper of particular merit accepted by the publication committee of any of the foregoing societies for publication, in whole or in abstract, in any of their respective technical publications, provided the author, at the time the paper is accepted in practically its final form, is not over 30 years of age.

The recipient of the prize is selected by a committee of 5, consisting of one representative of each society, the award being based upon papers published by the societies within the 12 months preceding July 15 of each year. The report of the committee is made to the board of direction of the American Society of Civil Engineers at its October meeting, which was held this year at Atlantic City, N. J., October 5–8. The award will be made to Mr. Starr by a representative of the American Society of Civil Engineers at a future meeting of the A.I.E.E.

# Last Year's Unemployment Relief to Serve as a Guide for the Future

PLANS for unemployment relief during the coming winter are being made in all sections of the country and must play an important part in the activities of engineers. A review of the work accomplished in various cities during the past year may be of assistance to those groups which are making plans for the coming season, and therefore is attempted in this article. Plans which are being formulated at present by different organizations will be announced soon and will be reported in future issues of ELECTRICAL ENGINEERING.

During the past year engineers in all sections of the country have proved themselves willing and anxious to assist their fellows, with the results that much good was accomplished and distress almost entirely eliminated. The assistance given took many forms, ranging from outright gifts to temporary or more permanent loans, the securing of temporary positions, many of these in "made" work, as well as the finding for many engineers of permanent positions in industry. It is generally felt that the results of last year's efforts warrant being sustained through the coming winter. In general, the needs which are anticipated seem to be not greatly different than those which existed last winter and the maintenance of the scale of the relief given last year should be adequate through the coming year. Too much stress, however, cannot be made of the fact that concerted and active effort is necessary immediately. Some of the novelty which relief workers experienced earlier in the campaign against unemployment has doubtless worn off and those engaged in the coming campaign realize that serious effort must be made.

## INSTITUTE SECTION ACTIVITIES

Activities of the Institute providing for unemployment relief have been carried on by the Sections. Following a resolution recommending such action, adopted by the Board of Directors at a meeting held October 23, 1931, Sections of the Institute throughout the country participated in the organization of committees of engineers, usually composed of representatives of all the engineering groups in the community, and cooperating with other local civic relief organizations.

Surveys have been conducted by these Section groups to determine the need for relief and the extent of local opportunities for constructive work or employment, using the aid of engineers who are at present unemployed as far as possible. Funds for loans to deserving unemployed engineers have been collected and administered.

Many valuable data have been collected by the questionnaires which have been sent out by many of the Sections. By this means the number of unemployed has been ascertained quite accurately, together with information on the urgency of the cases, and types of positions for which the individuals are fitted. A survey of the industries in each locality has disclosed many positions which could be filled to the advantage of both employer and employee. Surveys of municipal projects which could be undertaken have been a most important phase of the work. Efforts which for some time have been carried on to reduce the number of working hours both in government bureaus and industries is producing some results, although not as extensive as was originally hoped for.

Educational activities, particularly in the metropolitan areas, have done much to maintain the morale of those unemployed and to prepare them for other positions in industry. This activity, comparatively new, has assumed different forms, but the assistance of established educational institutions usually is secured in formulating courses and securing instructors.

**Table I—Classification of Placements**

| | |
|---|---|
| On P.E.C.U. payrolls | 308 |
| Receiving other relief, such as that given by the Gibson, Bliss, and general public committees in the metropolitan district of New York | 960 |
| In permanent engineering jobs | 246 |
| Total | 1,514 |

Many of the local committees, although active, have not supplied detailed information regarding their procedures and results, and consequently a full report on these activities cannot be made to other Sections of the Institute. However, in many cases the activities of Institute members have been so closely interwoven with those of other civic groups that no separate report could be given.

## NEW YORK CITY UNEMPLOYMENT ACTIVITIES

The plan developed for unemployment relief in the metropolitan district of New York, N. Y., was carried out during the past winter with considerable success. The details of this plan were described in ELECTRICAL ENGINEERING for March 1932, p. 205–7. The organization formed "The Professional Engineers Committee on Unemployment" is known locally as the "P.E.C.U." and represents the New York Sections of the 4 national societies of civil, mining, mechanical, and electrical engineers. The first meeting of the P.E.C.U. was held October 21, 1931.

In addition to other forms of activities and assistance, the New York sections of these 4 national engineering societies made up a separate fund to take care of overhead expenses of the P.E.C.U. The Institute's New York Section more than filled its quota, and secured a margin to start the coming winter. This fund was secured by donations of $1 from members of the Section.

Up to October 11, 1932 the P.E.C.U. had a total of 2,188 active registrants among unemployed non-members and members of the 4 national societies. In addition to these active registrants, over 500 others had registered but were not regarded as active applicants for relief, as they had registered for educational courses, did not reply to letters, or had later stated that they were interested only in permanent engineering positions, not in relief. Of the 2,188 active registrants, 1,514 placements have been made. These may be divided as shown in Tables I to IV.

## TYPE OF WORK SECURED

Of the 1,514 engineers placed by the P.E.C.U., 419 were placed with the Emer-

**Table II—Division Among Society Members and Non-Members**

| Society | Registered | % of Total Registration | Placed | % of Total Placed | % of Registered Placed |
|---|---|---|---|---|---|
| Am. Soc. of Civil Engrs | 240 | 10.9 | 204 | 15.2 | 85.0 |
| Am. Inst. of Metal. & Mining Engrs. | 35 | 1.5 | 33 | 2.5 | 94.3 |
| Am. Soc. of Mech. Engrs | 357 | 16.2 | 277 | 20.7 | 77.5 |
| Am. Inst. of Elec. Engrs | 212 | 9.6 | 173 | 12.9 | 81.6 |
| West. Soc. of Engrs | 4 | 0.3 | 4 | 0.3 | 100.0 |
| Non-Members | 1,349 | 61.5 | 648 | 48.4 | 48.3 |
| | 2,197 | 100.0 | 1,339 | 100.0 | |
| Duplicate membership | 9 | | 7 | | |
| | 2,188 | | 1,332 | | |
| Men placed more than once | | | 182 | | |
| Total | | | 1,514 | | |

### Table III—Analysis by Marital Status

| Marital Status | Registered | | Placed |
|---|---|---|---|
| Single | 655 | | 265 |
| Married | 1,449 | | 1,039 |
| Widower | 33 | | 18 |
| Divorced | 29 | | 10 |
| | 2,166 | | 1,332 |
| Unaccounted for | 22 | | |
| | | Replacements | 182 |
| Totals | 2,188 | | 1,514 |

### Table IV—Analysis by Salary Groups

| Previous Salary | Registered | | Placed |
|---|---|---|---|
| $6,000 or better | 130 | | 106 |
| $3,600–$6,000 | 512 | | 381 |
| $2,400–$3,600 | 1,028 | | 627 |
| $2,400 and below | 496 | | 218 |
| | 2,166 | | 1,332 |
| Unaccounted for | 22 | | |
| | | Replacements | 182 |
| Totals | 2,188 | | 1,514 |

gency Work Bureau, known as the Gibson committee, mostly in city bureaus, colleges, and universities, and relief work in this district. Men were employed in city departments for surveying, drafting, making mechanical plans and specifications for hospitals, for traffic surveys, as playground and gymnasium instructors, plan examiners for municipal buildings, and truant officers; as assistant professors, draftsmen, general office workers, stock men and laborers in colleges and universities; and for the collection of city relief funds and the carrying on of home relief investigations for other relief organizations.

The City Work and Relief Administration, known as the Bliss committee, took 392 of the men as key men in home organizations, timekeepers, checkers, payroll men, pay masters, and field men engaged by the heads of various city departments, mostly in construction and maintenance work.

In other organizations, 31 were engaged in a topographical survey, 44 for surveying in an outlying county, 64 by the Westchester County Park Commission, mostly for general laboring work, and 10 others in 3 smaller units.

The P.E.C.U. itself employed 60 salary workers on the home office staff for interviewing, registering, classifications, placement, payroll, consultation bureaus, investigations, and soliciting funds. A total of 248 others are paid directly by the P.E.C.U., but are assisting other organizations in a great variety of work.

Permanent engineering positions have been secured for 246 men. Some of these are not strictly engineering activities but may be classed as permanent positions.

## SOURCES OF FUNDS

The amount raised in cash and pledges, the number of contributors, and average amount individually contributed by the membership of the 4 national societies in the metropolitan district of New York are shown in Table V. The canvassing for this money was done in 3 ways: by letters of appeal; by unemployed engineers as canvassers or solicitors, they being paid the relief wage; and by voluntary committees of members of the societies doing personal canvassing. The letters of appeal were 4 in number. The first went to the 13,000 members of the 4 national societies in the metropolitan district of New York. The second, third, and fourth were sent to those who had not replied to the preceding letters, it being necessary to mail but 5,400 copies of the last letter. The engineers were divided into 2 classes: (1) a special group supposed to contain the more affluent members of the profession, to the number of 571; and (2) the remainder of the members. Contributors on the special list to the number of 183 gave $30,526.60, or an average sum of $166.80 each.

Of the total of $109,723.96, about $20,000 was originally in the form of subscriptions or pledge cards, the donor electing to contribute on a monthly or weekly basis over varying periods of time, some as long as 5 months. Experience indicates that only about $1,000, or roughly, 5 per cent of the total number of pledges are in default. In nearly every such case the pledger has lost his job since undertaking his obligation. The total sums obtained to May 15, 1932, are shown in Table VI. The first figure, $107,841.09, shown for that date corresponds to the figure of $109,723.96 shown in other tables as of October 11, 1932.

### Table V—Analysis of Contributions to Oct. 11, 1932

| | No. of Contributors | % of Total | % of Membership in Territory | Total Contributions | % of Total Contributions | Avg. |
|---|---|---|---|---|---|---|
| Civil | 787 | 22.46 | 22.5 | $ 34,547.38 | 31.4 | $43.90 |
| Electrical | 1,134 | 32.40 | 30.4 | 22,502.62 | 20.5 | 19.84 |
| Mechanical | 1,115 | 31.83 | 38.3 | 25,282.96 | 23 | 22.67 |
| Mining | 265 | 7.56 | 8.8 | 12,222.47 | 11.2 | 46.12 |
| Non-Members | 202 | 5.75 | ... | 15,168.53 | 13.9 | 75.09 |
| | 3,503 | 100.00 | 100.0 | $109,723.96 | 100.0 | $31.32 |

## TYPES OF RELIEF PROVIDED

The average relief afforded the individual unemployed engineer through the P.E.C.U. up to May 15, 1932, has been $19.05 per week; this sum has varied somewhat depending upon where the relief was obtained, as shown in Table VII. At that date there had been 73 loans granted in amounts in excess of $15, totaling $3,355, and averaging $45.18 per man. There had been 60 emergency loans granted in amounts less than $15, totaling $248 and averaging $4.13 per man.

These loans were on demand notes without interest. The expectation is that ultimately a considerable percentage of the borrowers will repay them. The funds so collected will be reserved for possible future use.

The relatively small number of loans made and the meager sums of money required surprised those active in the P.E.C.U. Apparently engineers (especially our members) are extremely loath to apply for loans. They much prefer wages from made work or even direct relief from city bureaus. Also, a loan meets only the momentary emergency.

The P.E.C.U. has been very active in persuading the gas and electric light companies to forebear enforcing routine orders to discontinue their services to destitute engineers. In some instances it has been possible to persuade holders of mortgages to be more lenient in the terms on which they extended or renewed them. Occasionally money has been loaned to pay interest on mortgages.

A legal aid department has been established, whose function has been to give free legal advice to registered unemployed whose circumstances were such that they required such advice. Similarly, an agency has been set up to assist registered unemployed who had developed inventions or processes possibly warranting patents. Assistance also has been given registered men in preparing letters outlining their past experience in a way to interest the prospective employer. This has been supplemented with a mimeographing service to produce multiple copies of such letters.

As regards clothing, the McGraw-Hill Company donated floor space and 2 unemployed engineers were set to work to operate a clothing bureau. On May 14, 1932, 203 men, 61 women, and 58 children had been provided with clothing, contributed largely through the efforts of the Engineering Woman's Club of New York. This clothing has been a godsend to many unemployed men, who, if they had not had

### Table VI—Total Sums Obtained to May 15, 1932

| | |
|---|---|
| Cash and pledges | $107,841.09 |
| Second-hand clothing, est. value | 4,500.00 |
| Unexpended balance of state and federal contributions for U.S. geological survey | 11,330.00 |
| Raised separately for administrative purposes to cover such items as postage and telephones | 5,247.00 |
| From President Hoover and the Engineers' Club of N. Y. for engineers outside the metropolitan district of N. Y. | 5,700.00 |
| Wages paid by semi-public bodies to P.E.C.U. engineers at the instigation of the P.E.C.U | 307,119.00 |
| Total | $441,737.09 |

### Table VII—Average Relief Afforded

| | |
|---|---|
| For those paid direct through P.E.C.U.'s payroll | $18.82 |
| For those who obtained relief through the Gibson, Bliss, and other relief committees | 21.50 |
| For those who got engineering jobs through P.E.C.U. and other sources | 32.50 |

the clothing, in many cases could not have taken the positions which were found for them. The Engineering Woman's Club not only collected and distributed clothing but also initiated and managed a charity bridge party. Some 700 tickets were sold at $2 apiece, the result being that a net contribution of $1,160 was made to the funds of the P.E.C.U.

Another successful activity was that of certifying unemployed engineers to Columbia University so that they could attend classes without academic credit and without expense. A total of 138 men made 564 registrations in 163 different courses for the winter and spring terms.

Another important committee which was recently established is known as the committee on industrial opportunities. This committee endeavors to place engineers outside the profession. It has prepared a list of some 800 industrial concerns which in its judgment could use engineers for cost studies and in other ways where their technical training and mathematical ability would make them more useful than the ordinary layman. This committee continued its work all summer, and has been reinforced by 2 other groups who solicit positions of a permanent nature. Members will greatly assist the P.E.C.U. if they will kindly inform the committee of any positions they may know of that might be filled by a man with engineering training.

Another committee, known as the committee on construction legislation, has been active in Washington and Albany in endeavoring to persuade congressmen and other legislators that the cutting out of construction enterprises from federal, state, and municipal budgets is fallacious economy, results in great increase in unemployment, and is particularly distressing to engineers.

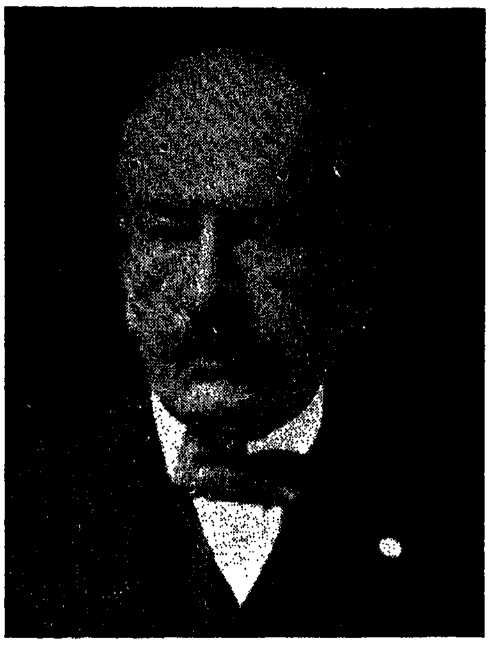
Reviewing the activities of the past winter, the P.E.C.U. feels that its greatest accomplishment has been to convince the semi-public relief agencies of the desirability, from their point of view, of using unemployed engineers in supervising capacities or as key men in directing the 35,000 or 40,000 individuals to whom these agencies have had to give unemployed relief in the form of made work or as direct relief. Extreme care was taken in certifying registrants to these public bodies, to make certain that the candidates sent were qualified for the job in question.

A large part of the work of the registration committee has been to classify all registrants as to their prior experience and their fitness for different types of work. Care along these lines in the early stages of the activities has been rewarded many times over.

### Summer Activities Curtailed

Registration of unemployed engineers ceased on April 9, 1932, as it was felt necessary to curtail relief work during the summer months and conserve funds for the coming winter. A small staff was maintained by the P.E.C.U. during the summer months, most of the attention being given to seeking permanent positions for the men, although the most destitute cases were carried throughout the summer. Plans for the coming winter are now being made, and will be announced in future issues of Electrical Engineering.

## In Memorium



C. O. MAILLOUX

On the fourth day of October 1932, the American Institute of Electrical Engineers suffered a great loss in the passing on of one of its most revered members, Dr. C. O. Mailloux.

Throughout Dr. Mailloux's career the cause of the Institute has been one of his foremost interests. From the early days of his activity in the organization meeting of May 1884, down through his many years of active service on the standards committee, the Edison Medal committee, the John Fritz Medal board of award, through his work on the United States national committee of the International Electrotechnical Commission, and the presidency of the Commission itself; his years as a director and vice-president of the A.I.E.E., his term as President in 1913–1914, Dr. Mailloux stood and fought for the ideals of the Institute, the maintenance of its high professional standing. Therefore be it

RESOLVED: That the Board of Directors at the meeting of October 12, 1932, record its deep appreciation of these many years of faithful, unselfish work carried on in behalf of the Institute by Dr. Mailloux, its realization of the loss which the Institute has suffered, and its sincerest sympathy to those from whose association he has been taken. And be it further

RESOLVED that this minute be spread on the offical records of the American Institute of Electrical Engineers and that copies be sent to his relatives.

—A.I.E.E. Board of Directors, Oct. 12, 1932

### Relief Program in Boston, Mass.

Following independent surveys initiated by the Boston Society of Civil Engineers and the Boston Society of Architects, it was decided toward the end of 1931 that the needs could be met best by cooperation between the professions of engineering and architecture. The Engineering Societies of Boston, composed of 12 member societies, immediately endorsed this plan and appointed an executive committee as well as the following 5 working subcommittees: finance, registration, administration, development, and publicity. As of June 16, 1932, a total of 198 engineers has been given employment, and 121 architects have been placed. A total of 865 engineers and 212 architects had registered on that date as being in search of employment.

The Emergency Planning and Research Bureau, Inc., was formed having 2 divisions, an engineers' division and an architects' division. Each of these divisions administers its own funds, selects the type of work which the men are to do, and keeps its own accounts, all these activities being coordinated through the board of directors of the bureau. The finance committee raises funds from employed members of the profession, these generally contributing one day's pay per month for a period of 20 weeks beginning January 24, 1932. Large organizations are covered by a team captain, and the Society members and other engineers are appealed to by letter. In this manner $79,004.62 was pledged by 2,429 individuals. On June 16, 1932, the period of the pledges not yet being up, $62,024.02 had been received.

Contributions received by the committee were credited to the amount received by the United Boston Unemployment Relief Committee, although the latter had nothing to do with the handling of funds collected by the engineers' and architects' bureau. Contributors to either fund were given the same card and button to avoid the annoyance of any one's being requested to donate to both organizations.

### Registration of Applicants

Each applicant registering with the bureau is asked for his exact financial condition in addition to the standard information on education and experience. If his financial condition is critical, the social welfare organization is asked to make a report on the case. This is reviewed by the registration committee, a member of which personally interviews each man. When the committee is satisfied of the need, the applicant is referred to the chairman of the administration committee, who places his name upon the payroll. He is then assigned to work in the drafting room of the bureau.

In determining the work which these men shall do, the development committee has followed 3 general principles:

1. The work shall not conflict with that of any employed engineer and it shall not take work away from any engineer.
2. The work must be of such a nature as to come within the classification of engineering.
3. Not only will the man himself be benefited, but there shall be a possibility that the project will open more work for the engineering profession or that it will be demonstrated that an engineer is the logical man for that type of work.

The projects are of a varied nature, and include:

1. Work for the City of Boston with the architects' division on mapping of city owned property and

blocking of the 1930 census, housing studies, depreciation studies of downtown business sections, and correction of maps for street changes for the planning board.

2. Work in connection with state departments for which there have been no funds available, such as fire protection studies at institutions, surveys in connection with public reservations, smoke investigations, traffic counts, plotting statistical data, surveys of state institutions, gathering of existing data on refrigerating and heating plants at state institutions.

3. Compilation of existing facts relating to New England that can be used for a regional study of this area, such as trends of population, transportation, local government finance, present status of zoning, and use of land in each county.

4. Library research work for committees of various engineering societies.

### EMPLOYMENT BUREAU

An employment service has been set up within the bureau and operated under state and city laws. No charge is made for services. Two employees of the bureau devote full time to this work, making contacts with organizations which ordinarily do not employ engineers, to "sell" the idea of using engineers. Previous to June 16, 1932, a total of 48 men had been placed in positions having an estimated total income of $10,640. In addition, 74 registered men have gone into work for which there is no income record, the yearly income of all men registered and now employed elsewhere being estimated at $210,000.

The executive director of the engineering division devotes his entire time and is responsible for the work done by the bureau, including the preparation of a weekly report. Office space and equipment have been donated by various organizations. The stationers and makers of blueprints furnish material at a substantial discount. The men work 7 hours per day, 5 days per week, at the rate of $3 per day.

The men receiving assistance are all married, with one or more dependents, the average being 3. For the 130 men on the payroll, the weekly disbursements average $1,600. The payroll expenditure to June 16, 1932 has amounted to $35,977.50, which is 98 per cent of the total expenditures of the bureau. Of the 865 engineers who have registered, 621 or 71.8 per cent, are non-members of any engineering society. The age analysis of registrants is shown in Table VIII.

**Table VIII—Applications in Age Groups**

| Ages | No. | Ages | No. | Ages | No. |
|---|---|---|---|---|---|
| 18–20.... | 6 | 31–35.... | 111 | 46–50.... | 32 |
| 21–25.... | 116 | 36–40.... | 108 | 51–60.... | 27 |
| 26–30.... | 162 | 41–45.... | 70 | 61–67.... | 6 |

**Table IX—Subscriptions to Oregon Technical Council Fund**

| Society | Total Subscriptions Paid In—Sept. 3, 1932 |
|---|---|
| Am. Inst. Mining & Metal. Engrs. | $263.00 |
| Am. Soc. Mech. Engrs. | 259.00 |
| Am. Inst. Elec. Engrs. | 774.00 |
| Prof. Engrs. of Ore. | 280.00 |
| Am. Soc. Civil Engrs. | 579.50 |
| U.S. Army Engrs. Unemployment Fund | 462.11 |
| Federal Employees Unemployment Fund | 439.53 |
| Miscellaneous | 5.00 |
| Total | $2,762.14 |

### RESULTS

Favorable publicity has been given the bureau by newspapers, speakers, and by exhibits at conventions and in clubs. The publicity director of one of the public utilities has assisted in this work. It is felt that the development of the welfare plan has resulted in the following benefits:

1. A better understanding among the individual engineering societies comprising the Engineering Societies of Boston.

2. A better understanding of the engineering profession by the general public.

3. The practical example of a well-planned and smoothly operating welfare organization, which has been cited as a model for other groups attempting to solve the relief problem within their ranks.

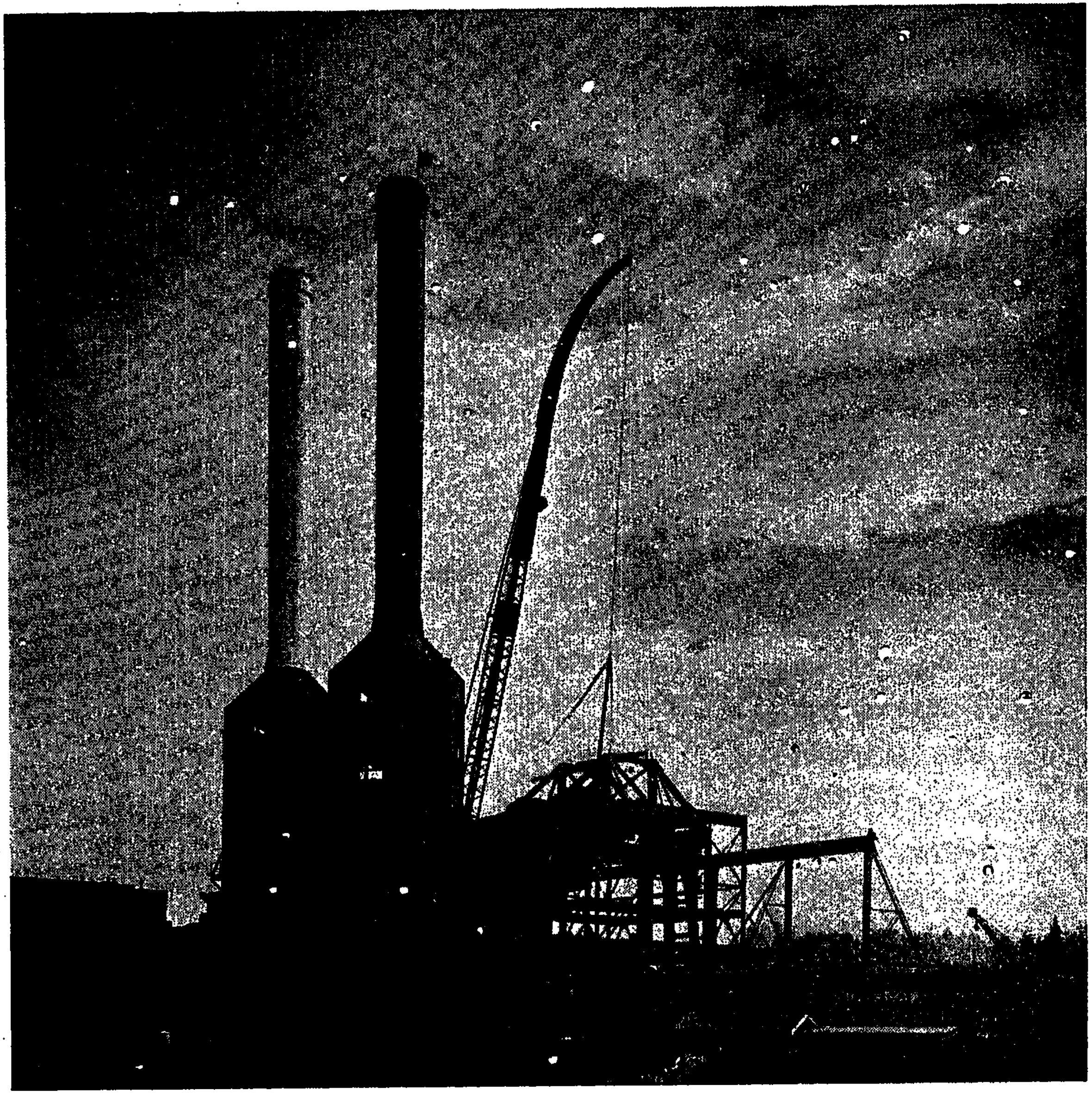
4. Improved morale of the unemployed engineer, who has been made to feel that he is producing work of value along the lines in which he has been trained, instead of feeling that he is a recipient of charity, giving nothing in return.

5. A closer relationship and a better understanding between the architects and engineers.

### ACTIVITIES IN SOME OTHER CITIES

Lack of space combined with incomplete reports unfortunately do not permit a comprehensive review of the unemployment work which has been accomplished throughout the country. Much of this work has been of tremendous value assuring employment for needy cases and in sustaining morale. The San Francisco Section of the Institute accumulated a sizable fund which

## New Mercury Vapor Turbine to Be Largest in Size



CONSTRUCTION of an unusual power plant to cost some $4,000,000 is being undertaken at Schenectady, N. Y., by the General Electric Company. Perhaps the most unusual feature is that a mercury boiler and turbine will be used, although no little interest is attached to the fact that it is to be the first outdoor steam-electric generating plant. The mercury turbine is rated 20,000 kw, and the station 25,000 kw, as there is also a 5,000-kw non-condensing steam unit. By-product steam will be secured from the mercury condenser; a steam boiler also will be included in the outdoor station. The electric output of the plant will be supplied to the commercial system of the New York Power and Light Corporation, while the steam output will be used in the General Electric works. The mercury vapor will be at a temperature of 958 deg F and 125 lb gage; the steam will be at 760 deg F and 410 lb initial pressure. It is contemplated that the plant will be ready for operation in the spring of 1933.

was used primarily in the form of loans to members or past members of this Section. An interesting procedure was followed by the California division of highways which maintains 2 camps where men are given the privilege of doing part time work on highway improvements in exchange for board and room. The men sent to these camps were distinctly above the average type of laborer in such camps, and were mostly young men. About 500 were cared for by this method.

An organization of unemployed engineers of Philadelphia, Pa., was formed for the purpose of keeping up the morale of their fellow engineers, and assisting employers in securing competent technical help. Approximately 1,000 men have been registered with this group, "The Philadelphia Technical Service Committee," and positions are being found in all branches of industry. (See ELECTRICAL ENGINEERING for July 1932, p. 526.)

As of May 28, 1932, the Engineers' Relief Committee of Pittsburgh, Pa., has collected $6,148.86, unpaid subscriptions amounting to $2,167.16. This has been expended as follows: $2,403.75 for 174 loans to be repaid by 55 individuals, $3,215.76 covering 230 contributions to 46 individuals, $146.10 for operating expenses, leaving a cash balance of $383.25. A total of 209 cases also had been handled at that time, 55 men having been placed in employment and 69 men paid from the committee's funds. Only the most destitute were assisted.

The Oregon Technical Council, Portland, has been disbursing funds for engineers' relief since March 10, 1932. A total of $1,750 has been loaned to 21 applicants. These loans usually run from $5 to $60, no applicant having received over $200. $2,762.14 has been paid by 121 subscribers, about $800 still remaining in the bank on September 3. The sources of the fund classified by societies are shown in Table IX. Plans for the coming year contemplate raising a larger amount from a much larger number of individuals, thus relieving the burden on those subscribing. These subscriptions are not donations, but are loans which will be returned as the loan notes are repaid.

The plan of the Rochester, N. Y., engineering groups last winter was to pool their interest with that of the American Engineering Council's committee on unemployment of western New York, which was organized to assist in promoting work which would bring more employment to engineers in this community. An emergency relief campaign also was organized in Rochester in which the citizens agreed to spend $6,000,000.00 during 3 months for improvements to their homes, factories, or offices. Of particular interest in this section is the "Rochester plan" which was organized by some 15 Rochester industries to assist in relieving unemployment in the State. This plan, quite well known throughout the country, does not become operative until 1933, but should be an important step in curbing future depressions.

# Letters to the Editor

CONTRIBUTIONS to these columns are invited from Institute members and subscribers. They should be concise and may deal with technical papers, articles published in previous issues, or other subjects of some general interest and professional importance. ELECTRICAL ENGINEERING will endeavor to publish as many letters as possible, but of necessity reserves the right to publish them in whole or in part, or to reject them entirely. STATEMENTS in these letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the American Institute of Electrical Engineers.

## Consumption, Production, Distribution

*To the Editor:*

The report on the present economic situation rendered by the American Engineering Council (see ELECTRICAL ENGINEERING for June 1932, p. 373–7) seems to me so far beside the facts, so full of obvious inconsistencies and direct contradictions, that, rather than give time to a discussion of the "Report" itself, I shall present hereafter certain specific conclusions I have reached as to the past performance of the existing economic system. Only in this way, I think, is it reasonably probable that any proper deductions as to cause and effect can be drawn.

The conclusions presented are drawn from a very extensive research and energy survey of North America now being conducted by "Technocracy" in the department of industrial engineering in Columbia University. The conclusions are reached through an application to the data of the theory of energy determinants.

The enormous quantity of associated data covering a large number of products over long periods of time and made available through this research proved to be the only source extant from which any direct conclusions could be drawn. Certainly no such data are to be found in any existing treatise or work on economics, nor do the publications of the several industries, our financial institutions, or of the Government, present the required information in logically assimilable form.

A considerable reading in the so-called science of economics has led me to the inevitable conclusion set forth by Veblen, that the foundation of this science rests upon the economic preconceptions of the 18th century, and that it merely attempts to describe our modern economy in these terms. Certainly no "law" of this science has been based upon thoroughgoing analysis of performance in fixed measured units. The "law of supply and demand" is an instance. It appears to me that economics was still in the state of physical science before the birth of Galileo. Nothing has yet been written that attempts to aline the performance of money and price with the performance of the production-distribution-consumption system in terms of a common unit of measure.

Physical energy is fundamental in modern civilization. If its flow ceased (no coal, no oil, no water power, no electric power) our civilization would cease and we would starve to death in 20 days or thereabouts.

The change from man-power at 0.1 hp per unit to mechanical power of unlimited hp per unit began in 1840, and since then has increased at a rate approximating the 8th power of the time. Double the time and our civilization has used $2^8 = 256$ times the power. Between 1830 and 1930 the amount of power used in the United States increased 360 times. At the present time we, on the average, use 150,000 kg-cal of energy per capita per day. Of this only 7 per cent is involved in sustenance (food). The remaining 93 per cent is used in making, distributing, and operating things not sustenance, such as automobiles, railroads, all applications of electric light and power, buildings, and clothing.

Put this measure on any living scale in any part of the world at any time, and much may be learned about the economy of that place and time. Previous to 1840 in all known civilizations, and in China today, the rate of energy dissipation did, and does not, exceed 2,000 kg-cal per capita per day. The implication as to social change and all its concomitants is obvious and significant. Mark you, this change from all of the past has taken place in not quite a century! Observe that, in spite of our vaulting assumptions, on this scale, our living "standard" in relation to our energy reserves is the lowest of any other people in the world!

At this present rate of consumption of energy all our available energy resources will have been used in a century (approximately). If the rate continues to increase as the 8th power of the time, then in 50 years from now, or by 1980, the rate of consumption of energy per capita will be 6,760,000 kg-cal per day. In such an impossible case our entire energy reserves of coal and oil would be used up at that time and all available water power would be entirely insufficient.

It matters not a rap what men think, wish, or desire. We are face to face with a law of nature. The law of conservation of energy has a perfectly definite social implication, and, as a corollary to that, a perfectly definite political implication! It follows that Malthius' law requires restatement in terms of energy.

The average production of all goods has increased since 1840 as the 3rd power (cube) of the time. Since 1890 production as a whole in 1928 had tripled. Some products have increased at much greater rates. Steel production has increased as the 6th power of the time. The continuation of such rates of growth is physically impossible. If the maximum rate of growth in coal production had maintained for 50 years, it would require that the whole earth be a solid ball of coal!

Meanwhile the man-hours used per unit of production has decreased at similar rates. In steel, the rate of decrease has been as the inverse 4th power of the time, in automobiles even greater. In pig-iron production one man-hour does today what 650 man-hours accomplished 100 years ago. In agriculture it requires but 1/3,000 of the man-hours per unit of product required in 1840. In incandescent lamp manufacture one man-hour accomplishes as much as 9,000 man-hours accomplished only so short a time past as 1914! One can go on indefinitely marshaling such facts. The ratio for the whole since 1840 is not far from 1/3,000.

The rate of decrease in man-hours as a

whole is greater than the rate of increase in production, and since 1918 the rate of decrease in man-hours has been approximately the same as the rate of increase in power efficiency of production. We are now substituting kilowatthours for man-hours on a parity basis—1,500,000 ft-lbs per 8 hours = 1 man.

If the rate of decrease in man-hours maintains for 50 years, there will be 20,000,000 unemployed in this country. At the peak of production in 1928 there were nearly 3,000,000 unemployed workers—an amazing fact when you first run into it. If the whole production plant were put to work at full capacity today, there would be about 6,000,000 unemployed workers.

Observe that, in spite of our technical supremacy, the energy efficiency of our civilization grows less at an accelerated rate! Deterioration of quality under the stimulus of competitive "cost" and its concomitant hastened obsolescence through use—in other words, waste—indicates one reason for the wide departure between the rates of increase in energy flow and increase in production, even after deducting the rate of substitution of kilowatthours for man-hours.

The above 3 fundamental facts, (a) the important place of physical energy in our civilization, (b) the growth rates of production which cannot maintain, and (c) the fact that the decrement in man-hours exceeds the growth of production, form the only proper basis for discussion of the present situation or future possibilities. The facts given are not wild guesses. They are a few resulting from careful analysis of much available data that has been checked several ways, and submitted to criticism.

Now to another matter. The industrial debt of this country—bonds, mortgages, bank loans, and all other interest-bearing amortized securities—totals approximately 218 billions. Taxes and obsolesence included, the fixed charges on this debt is 34 billions a year—practically half the national income of 1928! Since 1840 this debt has increased as the 4th power of the time. In other words, we owed in total 16 times as much in 1930 as we owed in 1895. The Government had in issue (June 30, 1931) about 6 billion certificates of debt in the form of demand notes called paper money. Add this to the 218 billions to get a grand total of 224 billions of debt based on 5 billions of gold, or roughly speaking, our money assets have to our liabilities the ratio of 1/50 or 2 cents on the dollar! The war debts are mere pocket change. What would be said of a manufacturing concern in such a financial position? What action on the part of the creditors would naturally follow?

Note that population has been increasing as the square of the time. Therefore the ratio of debt to population increases as $t^4/t^2 = t^2$, or as the square of the time. In 1930 each one of us on the average owed 4 times as much as we owned in 1895. If you think this cannot be correct, look up the data yourself.

Note also that while the debt increases as the 4th power of the time, production increases as the 3rd power of the time. It follows that the debt, which must be supported by the sale of produced goods, increases faster than the production of these goods. In other words, the goods are "put in hock" faster than they can be produced! How long, and by what kind of financial legerdemain, can such a proceeding be maintained?

Now in the light of such facts, consider the economic and financial promulgations issuing from the Hague, from Geneva, from Lausanne, and from Washington! Finally, examine the "reports" on the economic situation produced by American Engineering Council!

Indeed, it is true that "our bankers are debt merchants and economics has become the pathology of debt." Price and production have little relationship now, and ere long will have none. The obvious conclusion is that a production-distribution system, energy operated, cannot be controlled by price, and it is footless to try. Certainly our experience of the past century should show us how footless the attempt has been.

The machine is an agent of liberation. Each of our 35,000,000 workers now uses 3,000 energetic slaves in the form of 300 mechanical hp, each horsepower being the equivalent in work done to 10 human slaves. The machine as a whole actually requires but 2 (not 4) 8-hour days per week from each worker. Why should he do more when, as Russell says, "the morality of work is the morality of slaves."

Obviously each worker must have adequate purchasing power, even if he works but 660 hours or less a year. Well, why not give it to him. But if the facts set down above are fairly correct it is quite evident this purchasing power cannot be in terms of "price." The ingrained concept of price stands in the way of a clear comprehension of the economics of an energy system, quite as the ingrained Euclidian concept of the straight line inhibits a clear comprehension of a non-Euclidian space. Evidently the unit of labor or work—the man-hour—is not the proper measure of economic values for we are doing away with the man-hour.

Well, what is the answer? Certainly it is not contained in the report of the Engineering Council for one!

Very truly yours,
Bassett Jones (F'30)
(101 Park Ave.,
New York, N. Y.)

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Author's Note: The time rates given in the above are illustrative. The actual functions fitting the data are not simple functions of the time, but do not involve higher powers of the time than those given. Thus, I have expressed population growth as the square of the time $t^2$. That is sufficiently accurate for the present purpose. The actual population growth function for the United States is given by Pritchett, $p = 9{,}064{,}900 - 6281430t + 842377t^2 + 19{,}829{,}500 \log t$. For production of goods, the functions are oscillating, the power of the time given being the highest power in the equation of the axis of oscillation.

## European Broadcasting Stations

*To the Editor:*

In connection with the short notice on "European Broadcasting Stations," appearing in Electrical Engineering for September 1932, p. 666, it may interest your readers to get a few data about the equipment used to an increasing degree in European broadcasting stations.

Late in 1928 the Marconi Company in London, England, decided to install for the new Chelmsford station a high-voltage mercury arc rectifier for feeding the amplifiers, for which purposes otherwise thermionic valve rectifiers had been used, and which give satisfactory service but unfortunately have only a very limited life, thus enormously increasing the operating costs of such stations. With a mercury arc rectifier no such difficulty could be expected and in fact the equipment in Chelmsford operated with entire satisfaction since its first starting to operate in September 1929. This rectifier was designed for an output of 400 kw at d-c voltages of 9,000, 10,000, and 12,000 volts.

Based on these favorable results, the Marconi Company has later installed a number of similar rectifiers in the stations built for Warsaw, Poland (1,000 kw, 15,000 volts direct current), Muenster, Switzerland (270 kw, 12,000 volts) and Athlone, Ireland (460 kw, 13,000 volts), this latter station having first been opened for broadcasting the features of the Eucharistic Congress held in Dublin in June 1932. The German post administration followed this example and so far equipped 5 stations with high voltage rectifiers ranging from 360 to 1,170 kw and 12,000 to 13,000 volts direct current. Other equipments of this nature will soon be put into operation in Torino, Italy, and some other European stations.

This development, accomplished in the short period of 4 years, shows that mercury arc rectifiers as designed for this special purpose are bound to replace successfully thermionic valve rectifiers with their limited life period, and shows that they have already secured a firm place in modern radio station equipment.

Very truly yours,
Paul R. Sidler (A'31)
(New York Representative, 19 Rector St., New York, N. Y., of Brown, Boveri and Co., Baden, Switzerland)

## Engineering and Human Happiness

*To the Editor:*

Many of your contributors and correspondents on the subject "Engineering and Human Happiness" recognize in some measure that "man's life consisteth not in the abundance of the things which he possesseth," and that the fundamental condition for individual happiness is an inward or spiritual state characterized by peace of mind and love for one's fellow men. As to what power can create that fundamental condition, no answer is nearer the truth than that of Doctor Pupin in your March issue. (See Electrical Engineering, March 1932, p. 156–7.)

. . . Given a proper spiritual foundation, true happiness can exist with the minimum of physical necessities or even without them. Engineering as a factor in human happiness seems therefore to be mainly dependent upon the spiritual state of the individual and of society as a whole. Only when man is inwardly prepared for a right use of the gifts of science will the world be safe for engineering progress.

Very truly yours,
C. Kent Duff (A'28)
(University of Toronto,
Toronto, Ont., Canada)

## "Class O" Insulating Materials

*To the Editor:*

The A.I.E.E. standards committee in 1922 provided an additional class of insulating material, namely, "Class O—Cotton, silk, paper, and similar materials when neither impregnated nor immersed in oil."

The committee, possibly influenced by the business depression of 1921, acted in response to a demand for cheaper electrical apparatus. We are again in the midst of a far more serious business depression, and we now have abundant time to contemplate past history. Can we say that we were justified in abandoning the fundamental principles upon which dependable insulating materials are based? Does it pay to ignore the superior qualities of impregnated absorbent materials saturated with a suitable substance that replaces the residual moisture and air between its fibers—entirely covers its fibers and renders them adherent to each other and to the conductors—a substance that will not flow or evaporate during the operating service of the machines regardless of overloads or prolonged action of heat?

Why not repeal the 1922 amendment ("Class O" insulation) and while we are about it, omit the words "organic" and "inorganic" wherever mentioned, as we depend upon the useful blending together of all components to make one solid homogeneous winding structure.

In conclusion, may I say that enameled wire is in a class by itself, the most economical wire to make and to use. We don't have to impregnate the enamel coverings, and we could not if we would. We have now available ready-made, solventless, dry, and transparent varnish films (cellulose acetate films) to use as layer insulation for enameled wires; a combination that effectively eliminates varnish tanks and vacuum impregnators in magnet coil production thereby offering another argument for the elimination of "Class O" insulating materials from the A.I.E.E. standards.

Very truly yours,
H. W. Turner (A'03)
18 Troy Place, Schenectady, N. Y.)

## Engineering Foundation

### Selecting an Engineering Career

"Engineering: A Career—A Culture" is the title of a pamphlet having as its aim the assisting of young men, their parents, and teachers in high schools and preparatory schools, to answer the all-important question: Should the vocation of engineering be selected as an individual's career? Reliable information for answering this question is needed; romantic stories or enticing propaganda will not do.

The information presented in this pamphlet has been compiled by the educational research committee of the Engineering Foundation, in cooperation with the societies which its members individually represent, namely: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Chemical Engineers, and the Society for the Promotion of Engineering Education.

Following a general chapter upon engineering requirements and opportunities, chapters are devoted to the specific branches of engineering, namely: civil, mining, metallurgical, mechanical, electrical, and chemical engineering. Chapters also are included upon the preparation for engineering, and another upon the earnings of engineers. The purpose in preparing this pamphlet has been to provide as helpful vocational guidance as practicable for engineering as a whole and not for any particular group.

In the pages of this pamphlet much is told about what engineers do, and what qualities of mind and character a youth should have to become an engineer. There is information upon the schooling that the boy should have, and upon the engineering colleges; also upon the training after college is ended and professional work is started. Some idea of the nature of the pamphlet may be gained from the following excerpts taken from the chapter on electrical engineering:

"Electrical engineers must possess mathematical abilities even greater than those necessary to other engineers, for the thing with which they deal, electricity, is energy without material embodiment, and it can be treated only as a mathematical formula. Elsewhere we have pointed out the qualities of imagination required of civil, mechanical, and chemical engineers, who deal primarily with material forces and their relations. The electrical engineer's mathematical analysis of energy and of its applications leads him into a realm of almost metaphysical speculation. . . . Multiplex telephone and telegraph systems for carrying numerous messages simultaneously over the same wires, long distance cables where hundreds of circuits within a single sheath must be prevented from interfering with one another, and the distance effect from the extremely high tension power lines which cover the country, all present problems solved only after the most exacting mathematical analysis. . . .

"Within the corporations of this (electrical) industry most electrical engineers find their careers. From the very nature of the business, large groups have become the rule. Telephone, telegraph, radio, and power transmission imply the connection of many points into systems with interests and administration in common. Growth, too, has been so closely dependent on continued active research that the economy of cooperation in this activity also has aided in the formation of large corporations."

Following also is an excerpt from the chapter on preparation for engineering:

"Engineering is essentially a scientific pursuit founded upon mathematics and natural sciences. . . . You should be prepared to analyze ideas by the logical reasoning of science and with the accuracy of mathematics. . . . The surest indication of possession of the requisite mental ability is your demonstration of it in school. If you have been consistently in the upper half of your classes, or preferable in the upper third, it is probably that you do. . . . You should clearly differentiate between the man who builds things with his own hands (a mechanic) and the professional engineer who plans the things the mechanic builds. The engineer should cultivate his capacity to visualize the intended result of his plan, to see with his mind's eye the things he plans in 3 dimensions as if they were already built."

The pamphlet will be revised as frequently as found desirable and made available to persons in all parts of the country year after year. It is being made available through the local sections of the national engineering societies, the colleges and their alumni organizations, and the Society for the Promotion of Engineering Education. Copies can be obtained also from The Engineering Foundation at 29 West 39th St., New York, N. Y. In lots of 50 or multiples of 50, the price is $10 per 100 copies. For single copies and for lots less than 50, the price is 15 cents per copy. Orders may be sent at any time; 10 per cent discount is allowed for quantity orders with cash before December 31, 1932. Remittances should be made payable to The Engineering Foundation.

## Standards

### Revision of A.I.E.E. Standard No. 4

The standard for "Measurement of Test Voltages in Dielectric Tests," No. 4 in the A.I.E.E. series, has been revised through action of the standards committee on October 11, which action was confirmed by the Institute's board of directors October 12, 1932. The revision concerns paragraph 4–102, the first 6 lines of that paragraph to be revised to read:

"*Impedance of Testing Transformers.*—For accurate tests, the impedance of the testing transformer should be not greater than 20 per cent based on voltage and current at which the transformer is operated for any test."

Those having Standard No. 4 may obtain an insertion slip covering this change by writing to the standards committee at A.I.E.E. headquarters.

### Proposed Test Code for Synchronous Machines

A proposed "Test Code for Synchronous Machines" was submitted by the Institute's electrical machinery committee to the Institute's standards committee at its meeting of October 11, 1932. Publication of this code, the second in the series originally proposed by the standards committee, was recommended to the board of directors and approved by that body on October 12. The work of publication will get under way at once and a later notice of availability will appear as soon as the date of issue is known. The first code, "Transformer Test Code," has been out for comment since October 1931. There is no charge for copies. Address the standards committee at A.I.E.E. headquarters.

### Lightning Protection Code Is Revised

By the action of the Standards Committee on October 11, 1932, later confirmed by the board of directors, the revision of the "Code for Protection Against Lightning" as submitted by the sectional committee under the chairmanship of Dr. M. G. Lloyd was approved. The original code, developed under the joint sponsorship of the Bureau of Standards and the Institute, was approved by the American Standards Association in April 1929, and was issued as publication No. 92 of the Bureau of Standards. The present revision concerns parts 1 and 2 of the code covering protection of persons and protection of buildings and miscellaneous property. The revised code now will go to the American Standards Association for approval, as recommended by both sponsors, and a new edition eventually will be issued by the Bureau of Standards of the U. S. Department of Commerce.

## Wires and Cables

The 3 standards for wires and cables that were approved by the American Standards Association on May 21, 1931: (1) "American Standard Definitions and General Standards for Wires and Cables" (Revised A.I.E.E. No. 30); (2) "American Tentative Standard Specifications for Weatherproof Wires and Cables" (A.I.E.E. No. 72); and (3) "American Tentative Standard Specifications for Heat Resisting Wires and Cables" (A.I.E.E. No. 73) now are available in pamphlet form. Copies may be obtained through A.I.E.E. headquarters. No. 30 is 30¢ per copy and Nos. 72 and 73, issued as one pamphlet, is 20¢ per copy. A discount of 50 per cent on single copies is allowed to A.I.E.E. members. For a detailed statement relative to these pamphlets, see the August 1932 issue of ELECTRICAL ENGINEERING, p. 599.

# Personal

M. S. SLOAN (A'07, F'30) from 1928 through 1931 president of the New York Edison and affiliated companies, recently was appointed by the United States Chamber of Commerce as chairman of its committee on federal expenditures.

E. W. JUDY (A'26) operating manager of the Duquesne Light Company, Pittsburgh, Pa., recently became a vice-president of the Pennsylvania Electric Association, an organization with headquarters at Harrisburg, Pa.

G. E. LAKIN (A'25, M'30) who has been serving the National Electric Power Company, New York, N. Y., as electrical engineer now has removed to Greenville, Ohio, to become president of the Greenville Electric Light and Power Company.

J. H. SERVICE (A'22, M'30) who has been professor of physics and mathematics at Henderson College, Arkadelphia, Ark., left that position the latter part of September 1932 to become instructor in mathematics and physics at the Michigan College of Mining and Technology, Houghton, Mich.

CALVIN W. RICE (A'97, F'12) national secretary of The American Society of Mechanical Engineers, New York, N. Y., has been appointed a member of the National Research Council on the division of engineering and industrial research for a term of 3 years beginning July 1, 1932.

L. P. MORRIS (A'30) previously special research assistant on the electrical engineering staff of the University of Illinois, (Urbana) recently joined the television engineering department of the U.S. Radio and Television Corporation at Marion, Ind., where he will take up residence.

A. H. MCLEAN (A'21) deputy city electrical inspector of Portland, Ore., will head the Northwest Section of the International Association of Electrical Inspectors as its president for the ensuing year, according to reports from that organization's convention held at Wenatchee, Wash., September 6–8, 1932.

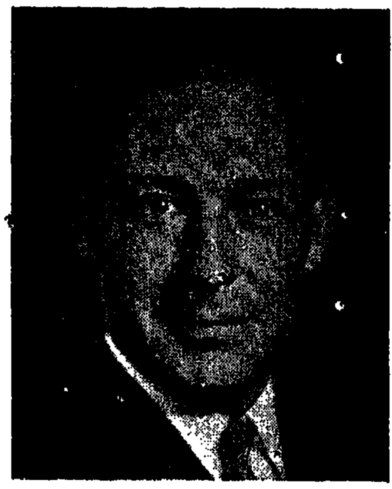
A. S. BROWN (M'30) formerly in responsible charge of all electrical engineering activities for the Federal Telegraph Company, Palo Alto, Calif., recently became associated with the Butte Electric & Manufacturing Company, San Francisco, as its manager. Mr. Brown was born July 1, 1889, in Minneapolis, Minn., received from Montana State College in 1910 the degree of Bachelor of Science in Electrical Engineering, and in 1915 the degree of Electrical Engineer. Before joining the Federal organization November 1928, he had had 7 years of electrical and radio experience with the United States Navy in positions of increasing importance, including service as radio engineer for the U.S. Navy at Mare Island, Calif., Cavite, P. I., Peking, China, and at the Naval Research Laboratory, Washington, D. C.

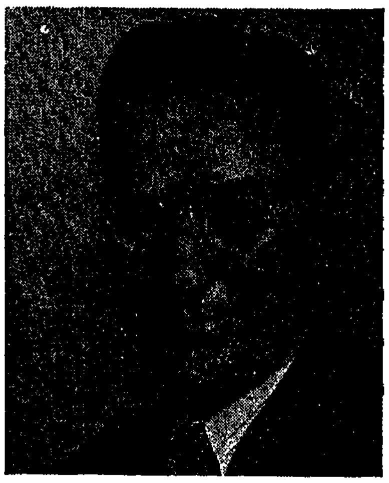
R. H. MARVIN (A'04, M'29) since June 1926 Engineering Foundation's "Research Fellow in Electrical Engineering" at the Johns Hopkins University, Baltimore, Md., recently became laboratory engineer for the Doble Engineering Company with headquarters at Medford Hillside, Mass. Doctor Marvin was born in Brooklyn, N. Y., October 27, 1879; received his M.E. degree in 1903 from Stevens Institute of Technology, Hoboken, N. J., his M.S. degree in electrical engineering in 1914 from Union College, Schenectady, N. Y., his Doctor of Philosophy from Johns Hopkins University in 1928. Prior to his work at Johns Hopkins he was successively: in the laboratory of the General Electric Lamp Works, Harrison, N. J. (1903–5); test department of the General Electric Company, Schenectady, N. Y. (1905–6); protective apparatus laboratory General Electric Company, Schenectady, N. Y., associated with the development of lightning protective devices and investigation of transmission system disturbances (1906–14); electrical engineer for The R. Thomas & Company, East Liverpool, Ohio, in charge of design and testing of high voltage insulators and line material (1914–18 and 1919–25); and first lieutenant, radio development department, Signal Corps, United States Army (1918–19).

STANLEY STOKES (A'16, M'21, F'29) consulting electrical engineer for the Union Electric Light & Power Company, St. Louis, Mo., was made a vice-president of the Institute representing the South West District (No. 7) by action of the Institute's board of directors, October 12, 1932. Mr. Stokes was appointed to serve until July 31, 1934, filling the unexpired term of G. A. Mills, formerly of Dallas, Texas, but recently removed to Lansing, Mich. Mr. Stokes was born in Columbia, Mo., February 19, 1890; started to school in Cambridge, Mass., while his father was doing graduate work at Harvard University. Continuing through the customary grade schools, he subsequently went to Kirksville (Mo.) State Teachers' College, then attended and subsequently (1912) graduated from the University of Missouri, with the degree of Electrical Engineer representing an additional year's work. In 1910 and 1911 during summer vacations he was with the Telluride Power Company, Utah, on telephone reconstruction work. During this period he received through the Telluride Association a scholarship at Cornell University of which he was unable to take advantage because of financial reasons. During the academic year 1911–12 he was student assistant in physics at the University of Missouri. Since 1912 Mr. Stokes has been associated continuously with his present or affiliated companies: 1912–14 with the Mississippi River Power Distributing Company as material clerk, estimator, and handling sundry other details incident to substation construction in connection with the Keokuk development; 1914–15, with the Electric Company of Missouri on cost analysis, rate schedule, and other such work, acting as assistant to the vice-president; 1915–16, sales engineer for the Electric Company of Missouri; 1916–18, superintendent of the Jefferson (Mo.) division of the Union Electric Light and Power Company in charge of transmission and distribution construction, and the conversion and interconnection of small local plants; 1918–25, manager of the outlying plant division of this company, serving also during this interval as vice-president and

STANLEY STOKES

general manager of the Commercial Telephone Company operating in Franklin County, Mo.; 1925–29, assistant vice-president in charge of electrical engineering and power supervision, in charge of construction of major transmission lines, and responsible to a large degree for important work in connection with the further development of the Keokuk hydroelectric plant and the complete layout of the Cahokia steam-electric generating plant, as well as the interconnection of these plants. Mr. Stokes' activities have included participation in the affairs of the St. Louis Section, for which he has served as secretary and also as chairman of the program committee. His technical writings include "Hinged Wooden Arms Used on Osage-Rivermines Line," published in ELECTRICAL ENGINEERING for February 1932.


J. W. BARKER


R. T. HENRY

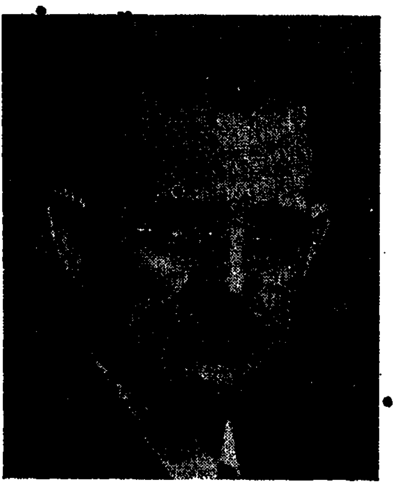
D. W. TAYLOR

**R. T. HENRY** (A'24, M'29) who now is electrical engineer in charge of design for the Buffalo, Niagara & Eastern Power Corporation, Buffalo, N. Y., has been chosen as chairman of the Institute's technical committee on protective devices for the ensuing year. Mr. Henry was born at Stronghurst, Ill., and acquired his preliminary education in the Niagara Falls high school graduating in 1907. He then attended the General Electric engineering school at Lynn, Mass., for one year and subsequently attended a summer session at the University of Michigan. In 1908 he engaged with the General Electric Company, at Lynn, as draftsman, a year later to join the Niagara Falls Hydraulic Power and Manufacturing Company, Niagara Falls, N. Y., in like capacity. In 1912 he became assistant electrical engineer of the Hooker Electrochemical Company, Niagara Falls, N. Y., where he was in charge of electrical construction. The next year he became designing draftsman of the Edison Illuminating Company, of Detroit, Mich., and in 1914 joined the Niagara Electric Service Corporation, Niagara Falls, N. Y., as assistant superintendent. Between 1918 and 1929 he was assistant electrical engineer of the Niagara Falls Power Company, the work involving supervision of the design and construction of additions to the generating stations at Niagara Falls, including 3 32,500-kva units and 3 65,000-kva units, together with the high tension and low tension switching stations, transmission lines, and underground cable systems. Since 1929 Mr. Henry has been electrical engineer in charge of design for the Buffalo, Niagara & Eastern Power Corporation, Buffalo, N. Y., this position really being a continuation of the previous one. Outstanding among the many features which this work has involved is the introduction of the small unit type distribution substation. Mr. Henry is a member of the National Electric Light Association, having been a member of its electrical apparatus committee and chairman of its protective equipment committee. He is a member of the joint committee of the N.E.L.A., A.E.I.C., and N.E.M.A. on oil circuit breakers. He was chairman of the Niagara Frontier Section of the A.I.E.E. for the year following August 1, 1929, and since 1931 has been a member of the Institute's committee on protective devices, of which he is now chairman. Through holding this office he automatically becomes a member of the Institute's technical program committee.

**J. W. BARKER** (M'26, F'30) dean of the engineering faculty at Columbia University, New York, N. Y., since early in 1930, has been elected president of the Illuminating Engineering Society for the year beginning October 1, 1932. Dean Barker was born June 17, 1891, at Lawrence, Mass. He pursued his education to graduation from Massachusetts Institute of Technology, Cambridge, in 1916 with the degree of Bachelor of Science, subsequently taking graduate work (1924–25) that led to his receiving from the same institution in 1925 the degree of Master of Science. After his graduation in 1916 Dean Barker went as a second lieutenant into the coast artillery of the permanent establishment of the United States Army, and was connected with the development of scientific methods in that service. He was a major in heavy artillery in the American Expeditionary Forces and, after the cessation of hostilities in 1918, served various commissions in France, Germany, and the United States. After his return to the United States he continued in the army as a high ranking captain in the Coast Artillery Corps, where he worked on important projects for sound ranging by electric methods. In September 1925, he resigned from the army to accept appointment as an associate professor of electrical engineering at M.I.T., in which capacity he served until 1929. During the academic year 1929–30 Dean Barker was professor of electrical engineering, head of that department, and director of the electrical engineering curriculum at Lehigh University, Bethlehem, Pa. In addition to his activities in the Illuminating Engineering Society he is a member of The American Society of Mechanical Engineers, the American Society of Civil Engineers, and the Society for the Promotion of Engineering Education. In Institute affairs Dean Barker's activities have included membership on the committee on production and application of light (1929–32); committee on education (1930–32); and technical program committee (1932–33).

**D. W. TAYLOR** (A'17, M'23) assistant electrical engineer of United Engineers and Constructors, Inc., Newark, N. J., has been reelected chairman of the Institute's technical committee on automatic stations for the current year. Mr. Taylor's birthplace was Cedar Rapids, Iowa. He attended high school in New York, N. Y., and received his E.E. degree from Columbia University. In 1916 he joined the electrical engineering department of the Public Service Electric Company, Newark, N. J., as cadet engineer. In 1918 he became engineering assistant, working principally on general substation design, system protection, and inductive coordination. As assistant engineer in the electrical engineering department of the Public Service Production Company between 1922 and 1925, he was in charge of relay protection for the system of the Public Service Electric Company. During this same period he also was division engineer in charge of the electrical engineering work for Hudson and Bergen divisions of the Public Service Electric Company. From 1915 to 1927 he was assistant electrical engineer, in charge of electrical design for the central division of the company. In 1927 he became assistant executive head of the electrical engineering department, checking all electrical estimates and supervising all electrical designs. Mr. Taylor was for 2 years a member of the relay subcommittee of the apparatus committee of the N.E.L.A., and was one of the editors of the N.E.L.A. Relay Handbook, writing the section on d-c protection.

**W. C. KALB** (A'12, M'15) since 1928 with the carbon sales division of the National Carbon Company, Inc., Cleveland, Ohio, has been appointed chairman of the Institute's technical committee on electrochemistry and electrophysics for the current year. Mr. Kalb was born at Arcadia, Ohio, and in 1904 was graduated from Ohio State University at Columbus, Ohio, with the degree of M.E. in E.E. After 3 years as mechanical engineer with The Columbus Pneumatic Tool Company, Columbus, Ohio, and a brief period of construction work with the Jeffrey Manufacturing Company, also located at Columbus, he engaged with the National Carbon Company and was placed in charge of its experimental laboratory for brush testing and development. In 1910 he left the National Carbon Company to become superintendent of The Dunlap Engineering Company, at first taking charge of production work and later supervising the sales department. In 1919 he became associated with the Corliss Carbon Company, and as general manager, continued with that company until it was purchased by the National Carbon Company, Inc. Mr. Kalb's present work there is in the advertising and technical publicity activities. His work on the Institute's committees has been continuous since 1929, when he was made a member of the committee on the production and application of light, and since 1931 he has served on the committee on electrochemistry and electrometallurgy, of which he now has become the chairman. He of course serves automatically also upon the technical program committee of the Institute, of which all technical committee chairmen become an integral part.



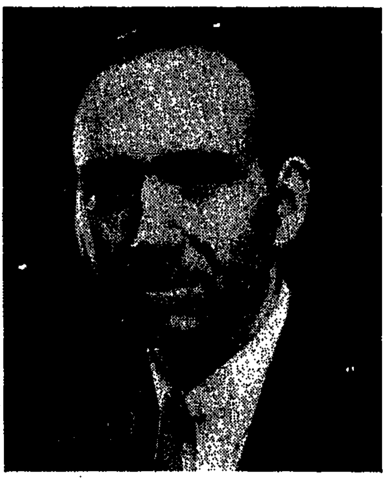
W. C. KALB

W. L. Emmet (A'93, M'94, Member for Life and past-vice-president) consulting engineer for the General Electric Company, Schenectady, N. Y., recently was the recipient of one of the John Scott Medal awards, administered by the Board of City Trusts, Philadelphia, Pa. Doctor Emmet, who already is the holder of over a hundred patents on electrical and kindred apparatus, received this award for his invention of the mercury vapor boiler and its practical application for power purposes. These awards, made annually from a fund established in 1816 by John Scott, a chemist of Edinburgh, Scotland, carry with them besides the medal, a certificate of achievement, and $1,000 in cash. Born at Pelham, N. Y., Doctor Emmet was graduated from the United States Naval Academy at Annapolis in 1881, serving as a cadet midshipman until 1883 aboard the U. S. S. "Essex." In 1887 he joined the Sprague Electric Company, then coping with electric railroad development in various sections throughout the country, and in 1889 was sent to Pittsburgh to superintend one of the largest electric railroad operations of the time. In 1890 he went with the Westinghouse Electric and Manufacturing Company, but only for a short time; he then removed to Buffalo, N. Y., to become electrical engineer for the Buffalo Railroad Company, a position which he again left almost immediately to join the Edison General Electric Company, then just formed, as its district engineer. In 1892 he was transferred to the company's New York office where he started as engineer in charge of the foreign department. In 1898 he re-entered the Navy as junior lieutenant, serving as navigator on the U. S. S. "Justin" during the Spanish War period. In 1900 he started his work of developing the Curtis Steam turbine, the first installation of which at Newport, R. I., proved his great success in this undertaking. Besides the Edison Medal which was awarded him in 1919 for his "invention and development of electrical apparatus and prime-movers," Doctor Emmet has been the recipient of the Franklin Institute's Elliott Cresson Medal "for discovery or original research adding to the sum of human knowledge irrespective of commercial value, of leading and practical utilization," and the Gold Medal of The American Society of Mechanical Engineers, awarded for "distinguished service in engineering and science." He is a member of the American Philosophical Society, the Society of Naval Architects and Marine Engineers, the Naval Consulting Board of the United States, the National Academy of Sciences, and The American Society of Mechanical Engineers.

R. D. Mershon (A'95, F'12, and past-president) recently had conferred upon him, for valuable service rendered the cause of national defense, honorary life membership in the Reserve Officers Association of the United States. The ceremony took place at the annual convention of that association. Mr. Mershon's memberships in technical and scientific organizations include the U.S. national committee of the International Electrotechnical Commission, the Inventors Guild (past-president) the American Society of Civil Engineers, the American Electrochemical Society, the Franklin Institute of the State of Pennsylvania, the Canadian Society of Civil Engineers, The American Society of Mechanical Engineers, the American Association for the Advancement of Science, the British Institution of Electrical Engineers, the Société Internationale des Électriciens, the University Club, Engineers' Club, and Lawyers' Club, of New York, and the St. James Club, of Montreal.

A. H. Babcock (A'04, M'06, F'12) past vice-president of the Institute (1918–19) and for some time consulting electrical engineer of the Southern Pacific (railroad) Company with offices at San Francisco, Calif., retired from office September 1, 1932, after 30 years of continuous service with that company. Mr. Babcock was born at Buffalo, N. Y., August 12, 1865. In the course of his technical training he attended both the University of California, Berkeley, and Lehigh University, Bethlehem, Pa. From November 1891 until July 1898 Mr. Babcock was associated with the San Francisco office of constituent companies of the General Electric group, and from July 1898 until July 1902 was in responsible charge of development work in hydroelectric plants and distribution systems for the Standard Electric Company (Calif.), a pioneer in the California electric utility field. In 1902 he entered the railway field as electrical engineer of the North Shore (Calif.) road, and laid out the first electrification of a steam road to be undertaken on the West Coast. Upon completion of this work he was made electrical engineer of the Southern Pacific system, and later, of all the Harriman lines comprising the rail network from New Orleans and Omaha to the Pacific, and from Spokane, Wash., to Mexico City, and since that time has been responsible for every electrical project of the Southern Pacific. In 1924 he was principal delegate to the Inter-American Commission on Electrical Communication, held in Mexico. As the result of this conference and subsequent discussion with naval officers, he was commissioned for a special service in demonstrating the application of short-wave radio transmission to naval communications. In 1925 he went with the fleet on its Australian cruise, and as the result of his work at that time the navy immediately adapted its communication service to the use of the short waves. Genuinely interested in all new electrical developments, Mr. Babcock also found time for many scientific activities in addition to his regular professional duties. He is a member of the Association for the Advancement of Science and of the Astronomical Society of the Pacific. He is a charter member and past-president of the San Francisco Engineers' Club, and an honorary member of La Sociedad de Geografia Y Estadistica. In addition to serving in other capacities, Mr. Babcock was chairman (1915–16) of the A.I.E.E. San Francisco Section.

F. M. Starr (A'30) of the distribution systems section of the central station engineering department of the General Electric Company, Schenectady, N. Y., has been awarded the 1932 Alfred Noble Prize for his paper "Equivalent Circuits—I," as reported elsewhere in this issue. This paper was presented at the A.I.E.E. winter convention, New York, N. Y., January 25–29, 1932. Mr. Starr was born in Fowler, Colo., in 1905, and was graduated from the university of Colorado in 1928 with the degree of B.S. in E.E. In June 1928 he entered the testing department of the General Electric Company at Schenectady, N. Y., and a year later was transferred to the engineering general department. Two years ago he entered the distribution systems section of the central station engineering department, the position which he now holds. He also has taken the company's 3-year advanced course in engineering.



F. M. STARR

Paul Lebenbaum (A'04, M'13) recently was promoted from assistant electrical engineer for the Southern Pacific (railroad)

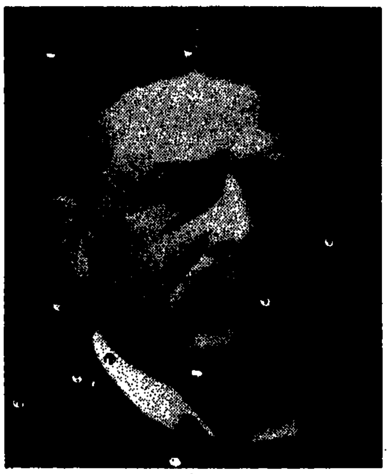
Company, San Francisco, Calif., to the office of electrical engineer for that company to succeed A. H. Babcock who retired as reported elsewhere in this issue. Mr. Lebenbaum was born in San Francisco, Calif., October 20, 1879. After attending the public schools of that city he entered the College of Mechanics at the University of California, Berkeley, whence he graduated in 1902, immediately to join the test department of the General Electric Company. After serving in that department from May 1901 to May 1902, he served in the company's drafting room until October 1902, subsequent to which he spent a year with the North Shore (Calif.) Railroad, during its electrification. Since 1903 he has been with the Southern Pacific Company. Mr. Lebenbaum has been active in Institute circles on the Pacific Coast, and has served the San Francisco Section in various capacities.

S. H. Mortensen (A'09, M'12, F'20) with the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., since 1908 has been appointed by that company as its engineer-in-charge of alternating-current design, succeeding R. B. Williamson who died June 26, 1932, as announced in Electrical Engineering for August. Mr. Mortensen was born in Eskelund, Denmark, November 4, 1878; was naturalized in 1908. After varied and extensive schooling and apprentice experience he graduated in 1902 from Polytechnicum of Mittweida in Germany, with degrees of Electrical and Mechanical Engineer. In the United States he first served with the Westinghouse Electric and Manufacturing Company (1903–5) and next with the Bullock Electric Company of Cincinnati, Ohio (1905–8) before his connection with his present company.

G. A. Mills (M'18) until recently an active leader in Institute affairs in the South West District (No. 7) has moved to Lansing, Mich. Mr. Mills, formerly chief engineer for the Central and South West Utilities Company and vice-president for the Pecos Valley Power and Light Company, Dallas, Texas, now is president of the Michigan Gas and Electric Company and the Michigan Public Service Company. As a result of his removal from the South West District, Mr. Mills resigned his Institute vice-presidency representing that District. Mr. Mills was to have served for the 2-year term, August 1, 1932–July 31, 1934. Stanley Stokes of St. Louis is his successor, as announced elsewhere in these columns. A complete biographical sketch of Mr. Mills is given on p. 54 of Electrical Engineering for January 1932.

L. A. Kelley (A'21) since 1929 a senior engineer on the staff of the International Communications Laboratories, New York, N. Y., now is a partner in the communication engineering firm of Burkholder and Kelley of New York, N. Y., and Toronto, Ontario, Canada. Mr. Kelley's previous experience includes service with the Signal Corps of the United States Army (1918–19); toll systems development department of the Western Electric Company (1920–24); and subsequently the department of development and research of the American Telephone and Telegraph Company. With the I. C. Laboratories Mr. Kelley was engaged in the design and development of new types of communication systems for use by affiliated companies.

H. S. Bennion (M'27) since September 4, 1926, director of engineering for the National Electric Light Association with offices at that organization's headquarters in New York, N. Y., recently was appointed assistant executive director of the N.E.L.A., according to announcement. Major Bennion was born September 7, 1889, at Vernon, Utah. He graduated from the United States Military Academy at Westpoint, N. Y., in 1912, and from the United States Engineers' School, Washington, D. C., in 1915. From graduation his military activities and service on various government commissions, including extensive service in France, continued up to the time of his original appointment to N.E.L.A. in 1926.


G. C. WARD

G. C. Ward (M'24) for 3 years executive vice-president, and since early in 1932 senior vice-president, of the Southern California Edison Company, Ltd., Los Angeles, Calif., has been named its president by action of the company's board of directors, according to press dispatches under date of October 19. As reported in Electrical Engineering (March and April 1932, p. 140 and 213) Doctor Ward has been identified with utility engineering and construction since 1882, and with the Edison Company since 1917 when it absorbed the Pacific Light and Power Corporation of which Doctor Ward was president.

W. A. Danielson (A'09, M'30) major, Quartermaster Corps, United States Army, recently has been assigned to duty as constructing quartermaster with headquarters in Baltimore, Md., from which he will direct construction of hospitals and quarters at Edgewood Arsenal, Camp Holabird and Forts Meade, Howard, and Hoyle. Major Danielson was transferred to Baltimore from Governors Island, New York, where he was on duty as utilities officer for the Second Corps Area. Previously he had been stationed at Washington, D. C.

P. H. Powers (A'21, M'30) vice-president in charge of sales of the West Penn Power Company, Pittsburgh, Pa., recently was elected president of the Pennsylvania Electric Association. Mr. Powers' work with the West Penn interests began in his capacity of division manager of the Keystone Power Corporation at Bellefonte, Pa.; in 1924 he was made general manager of that company and in 1928 he became commercial manager of the West Penn Company at Pittsburgh, Pa. Appointment to the vice-presidency followed in 1930.

H. R. Reed (A'28) has been promoted from assistant to associate professor of electrical engineering in the Michigan College of Mining and Technology, Houghton. Professor Reed went to Michigan Tech. in the autumn of 1929 from South Dakota State College, Brookings, where he had been an instructor since receiving his M.S. degree from the University of Minnesota in 1927. His special field of interest is transient electrical phenomena, in which he conducts senior and graduate courses and carries on research work.

W. P. Schwabe (A'96, M'24) manager and director of the Northern Connecticut Power Company (now affiliated with the Connecticut Light and Power Company) Thompsonville, Conn., and a past-president of the New England Division of the National Electric Light Association, has been appointed a director of the Federal Home Loan Bank for the New England district. His headquarters will be at Cambridge, Mass.

J. C. Burkholder (M'30) formerly chief engineer of telegraphs for the Canadian National Railways, Toronto, Ontario, now is senior partner in the recently formed communication engineering firm of Burkholder and Kelley of New York, N. Y., and Toronto. Mr. Burkholder has been widely known for the successful accomplishment, under his direction, of communication with moving trains, and other related developments.

F. J. Rudd (M'19) who heretofore has been serving the General Electric Company, Schenectady, N. Y., as designing engineer of its motor department, now becomes manager of the stationary motor engineering department upon the transfer of L. E. Underwood (A'03, M'13) to the managership of the Pittsfield (Mass.) works (see Electrical Engineering, October 1932, p. 748).

B. C. J. Wheatlake (A'16) manager of the Salt Lake City, Utah, office of the General Electric Company, has been chosen to care for the arrangements in connection with the Institute's 1933 Pacific Coast Convention, as convention chairman. Mr. Wheatlake already is well known in his local Section activities, in which he has been participating now for some time.

D. W. McLenegan (A'24) who has been serving the General Electric Company at Schenectady, N. Y., as commercial engineer in its industrial engineering department, recently received appointment to the office of assistant engineer of the commercial engineering division of the company's air conditioning department, the formation of which took place only this year.

**E. R. Hedrick** (M'25) professor of mathematics and chairman of the department of mathematics of the University of California at Los Angeles, Calif., has received appointment to the chairmanship of the committee on the teaching of mathematics in colleges and universities of the North Central Association of Colleges and Secondary Schools.

**D. R. Bullen** (A'02) assistant vice-president of the General Electric Company, Schenectady, N. Y., recently was elected second vice-president of the National Electrical Manufacturers Association, New York, N. Y.

**O. A. Demuth** (A'23, M'30) formerly an electrical engineer with the Stone & Webster Engineering Corporation, Seattle, Wash., now is associated with 4 other former Stone & Webster engineers in the Shannon Engineering Company, Seattle, Wash.

**C. W. Mitchell** (M'31) was reelected secretary-treasurer of the southwestern section of the International Association of Electrical Inspectors, at the Santa Barbara, Calif., convention of that organization held September 12–14, 1932.

**R. H. Goodwillie** (A'04) works manager of the Otis Elevator Company, N. Y., recently was elected treasurer of the National Electrical Manufacturers Association, New York, N. Y.

## Obituary

**Charles F. Goob** (M'21) chief engineer for the Baltimore, Md., department of public works, died in Baltimore, September 26, 1932, after a short illness. Mr. Goob was born January 1, 1884, in Baltimore, where he subsequently pursued his education, graduating from the Baltimore Polytechnic Institute in 1901, and completing a postgraduate course there in 1902, in addition to which he pursued a similar course in the mechanical laboratory at Lehigh University, Bethlehem, Pa. From 1902 to 1907 he was successively engaged as a cable tester for the Maryland Telephone Company, draftsman in the chief engineer's office of the Baltimore & Ohio Railroad Company, and draftsman on telephone switchboards for the Western Electric Company at its Hawthorne works, Chicago, Ill. In 1912, acting for the Wilson Maltman Electric Company, he installed all mechanical equipment in the then new Baltimore Polytechnic Institute, where he continued as an instructor of engineering until 1917. From April 6, 1917, until August 31, 1920, Mr. Goob served as an engineer officer in the United States Navy with the rank of lieutenant. Upon his discharge from the navy he became associated with the Electrical Commission of the city of Baltimore as its chief engineer, subsequently heading the bureau of mechanical-electrical service in the Baltimore city government, later becoming the city's chief engineer, a position he filled until his death.

**Cyprien O'Dillon Mailloux** (A'84, M'84, F'12, Life Member, past-president) widely known for his active participation in international engineering and scientific standardization work, and for many years prominent as a consulting engineer in New York, N. Y., died suddenly October 4, 1932, at the age of 71, at his home in that city. Dr. Mailloux was a charter member of the Institute and had served it actively and generously through many years. He served 3 terms as manager (1886–9, 1899–1902, 1905–7) 2 terms as vice-president (1898–9, 1902–4), served as president for the year 1913–14, and devoted many years to the Institute's committees including the standards committee, the Edison Medal committee, and the John Fritz Medal board of award. Dr. Mailloux was born at Lowell, Mass., but at an early age he went to New York City where, in pursuit of professional learning, he was one of the leading pupils of Dr. Pupin who at that time was a lecturer on advanced theory of electrical engineering at Columbia University. In its later application, Dr. Mailloux's professional career touched many and diverse channels. In specifically technical work over a period of 25 years, his activities included "responsible charge" and direction of electrical work on more than 800 jobs ranging from 50 to 25,000 kw; perfection of some 100 inventions of which 30 were patented by him, some of these including patents rated as "basic" in connection with the circuit breaker, the booster for d-c circuits, the non-differential d-c arc lamp, and the iron clad multipolar street-car motor. He spent appreciable amounts of time, in addition to his design and construction work, in the giving of expert advice and counsel, the preparation of statistics and reports, and in arbitration work involving many difficult situations that would have sorely taxed many less capable or less patient and persistent. In this last mentioned capacity his extensive knowledge of languages made it possible for him to be the forceful prominent figure that he became in connection with the first, and many subsequent, meetings of the International Electrotechnical Commission. With his ability as an interpreter and his keen insight he soon found himself in the rather vital rôle of liaison officer. In the I.E.C. Dr. Mailloux has been president (1919–23), director, secretariat on nomenclature, and at the time of his death, honorary president; and on the U.S. national committee of the I.E.C., he has been president (1914–24) chairman, advisor on nomenclature, representative on division of foreign relations. In the International Conference on Large Electric High-Tension Systems in Paris, he was honorary president, acting also as United States delegate at recent biennial meetings. Today the I.E.C. probably is one of the largest cooperative international factors working for the advancement of the electrical profession. Doctor Mailloux was an ardent advocate of a universal language on technical terms—a scientific *esperanto*—which he contended would give the United States, already controlling a heavy percentage of the world's electrical industry, a medium almost invaluable for the promulgation of professional progress. Dr. Mailloux was a liberal contributor to technical literature, and through his effort the electrical engineering nucleus of the present Engineering Societies Library in New York had its origin. In 1902–3 he, himself, donated certain volumes and subscriptions to certain technical periodicals to the library of the electrical engineers, providing maintenance for these sets of books and periodicals by a gift of $1,000 "to be . . . invested . . . the proceeds . . . to be used partly each year for the subscription . . . to the serial publications donated and partly for the binding of said publications." Administration of this fund, still extant and known as the Mailloux Fund, subsequently was modified by the donor to permit the expenditure of moneys accruing from it for "books, periodicals, or other publications in the French language relating to either electrical engineering, mathematical physics and pure mathematics"; its present application represents a still further broadening of these stipulations to include writings other than in French.

**Frederick William Kelley** (A'05) president of the North American Cement Corporation, Albany, N. Y., and former president of the Albany Chamber of Commerce, died September 19, 1932, after a period of continued ill health. Albany was his birthplace (1870) and after attending the Albany Boys Academy for a while, he went to public school in Toledo, Ohio, later also attending the Toledo Manual Training School. In 1893 he was graduated from Cornell University with his degree of M.E.; during this course he took considerable electrical engineering work also but not enough to win him an additional degree. In 1894 he was engaged by the Consolidated Car Heating Company of Albany as draftsman, but so successful a career did he create for himself that he became successively assistant treasurer, treasurer, and general manager of his firm. In 1900 he joined the Helderberg Cement Company of Albany and until 1905 was its vice-president and general manager. In 1925 his company merged with the Security Cement and Lime Company of Maryland and Mr. Kelley who in 1914 had been elected president of his own company now became president of the new organization, the North American Cement Corporation. He later became president of the Portland Cement Association of America. Various other organizations of which he was a member and an officer at the time of his death include: the National Commercial Bank and Trust Company, vice-president; City Savings Bank, trustee; Consolidated Car Heating Company, director (and former president); Albany Hospital, president; Albany Medical College, Albany Academy, Albany Institute of History and Art, and the Dudley

Observatory, trustee; Commercial Safe Deposit Corporation, director; and a member of the board of governors of Union University. Mr. Kelley also held membership in The American Society of Mechanical Engineers, the American Society for Testing Materials, the American Concrete Institute, the Albany Society of Engineers, and the Society of Engineers of Eastern New York, of which he was a past-president.

**Harry Alexander** (A'91, M'17, F'20) long-time electrical contractor with headquarters in New York, died October 18, 1932, at his home in Kings Point, N. Y., as a result of gunshot wounds obviously self-inflicted. It is reported that Mr. Alexander had been suffering for some years from heart trouble. Mr. Alexander was born August 6, 1871, in New York City, according to his A.I.E.E. application made under date of April 21, 1891, although current newspaper reports give Lynn, Mass., as his birthplace. After a common school education he is credited with continuing his education through reading, night study, and practical experience. He was early (1888) connected with the Thomson-Houston Electric Company at Lynn, subsequently becoming a machine shop superintendent for the Thomson Van Depoele Company of Dover, N. H., manufacturers of mining machinery. In the latter part of 1891 he went to New York City as a member of the electrical contracting firm Alexander-Chamberlain Electric Company, which later in the same year became Harry Alexander, Inc. Electrical installations credited to him include the White House in Washington, D. C., and stores and office buildings in various eastern and middlewestern cities including New York, Baltimore, St. Louis, and Boston. He is credited with being the contractor for the original East Side (N. Y.) terminal work of the New York Central Railroad in connection with its Grand Central station (1907); patenting an interior conduit system (1906–7); being a sub-contracting engineer for substation and construction work for the United Railway of Havana (1909); and with patenting the "Alexalite" indirect lighting diffuser (1911). During 1917 and 1918 he was associated with the provision of electric power facilities at the U.S. naval transport terminal in Hoboken, N. J. He was a member of The American Society of Mechanical Engineers.

**Malcolm Percy Ryder** (A'01, M'14) mechanical and electrical engineer at Westfield, Mass., died suddenly May 24, 1932 of heart disease. Mr. Ryder was born in Ossining, N. Y., February 22, 1874, and after high school attendance acquired his early technical education chiefly by home study in conjunction with such practical work as he found. In 1890 he engaged with the Edison Machine Works, predecessors of the General Electric Company, Schenectady, N. Y., taking the student course in shopwork and spending a considerable amount of time in the testing department. In 1892 he went to the Thomas A. Edison iron ore separating works in charge of separators and the electrical plant, a year later joining the General Electric Company's Lynn Works for a special course in arc lighting and a-c work. The year 1893 was spent in Maracaibo, Venezuela, in charge of the central station of the Maracaibo Electric Light Company; then he returned to New York as electrical engineer in charge of the central station of the North River Electric Light and Power Company, later to become its superintendent of central stations for a period of 2 years. The C & C Electric Company of Garwood, N. J., called him as foreman of the winding and testing departments for a year, after which he returned to New York City as wire contractor. In 1899 the New York Edison Company made him superintendent of its Bronx District, a position which he held until 1909, when he removed to Springfield, Mass., to become engineer of the Witherbee Igniter Company, in charge of design and production of ignition apparatus for internal combustion engines. He later invented a novel type of magneto generator which was manufactured by the Witherbee Company. Remaining with this firm until 1919 he then withdrew and took up residence in Westfield, Mass., his home at the time of his death.

**William Lamb Dodge** (M'26) telephone engineer, Bell Telephone Laboratories, Inc., New York, N. Y., died April 7, 1932. Mr. Dodge was born at Clinton, Maine, in 1885, and in 1902 attended Coburn Institute, subsequently winning his degree of A.B. from Colby College, Maine, in 1906. For 2 years thereafter he was engaged in a student course of the Western Electric Company, working also in the installation department of that company. In 1908 he identified himself with the plant department of the New York and New Jersey Telephone Company, a year later joining the plant department of the New England Telephone Company. Here he remained until 1917, when he engaged with the Western Electric Company's engineering department and the Bell Telephone Laboratories, first for the design of manual and machine switching telephone systems, later as engineering department representative in charge of a group of engineers on the first panel machine switching central office placed in service, and still later for $3^1/_2$ years in charge of one or more groups of engineers engaged in the design of machine switching systems of the panel type and the step-by-step type. Mr. Dodge's work has involved the engineering of many important projects and has placed him in charge of highly essential development work.

**J. R. Gilroy** (A'26) injured in an automobile accident May 1, 1932, died September 5 as the result of the accident. Mr. Gilroy was injured at Champaign, Ill., where he had been living while attending the University of Illinois at Urbana. Mr. Gilroy was born in Scotland, June 29, 1903, but pursued his grade and high school education in the United States, after which he graduated from Bliss Electrical School in Washington, D. C., subsequently attending Armour Institute of Technology in Chicago during the period of his employment in the testing laboratory and later in the operating department of the Commonwealth Edison Company of Chicago.

**Neel Bullock** (A'32) who this past summer completed his college course at the University of Alabama, University, Ala., and obtained his degree of B.S. in E.E., was accidentally drowned in St. Andrews Bay, St. Andrews, Fla., August 21, 1932, while out with a boating party. Mr. Bullock was born in St. Andrews, December 20, 1909. He had spent the summer of 1930 in the drafting department of the Southern Kraft Corporation.

# Local Meetings

## Future Section Meetings

**Detroit-Ann Arbor**

November 15, at Jackson, Mich.—SWITCHGEAR. To be discussed by members of the local Section.

December 13, at Detroit, Mich.—ELECTRIC MOTORS AND THEIR APPLICATIONS, by A. M. Dudley, Westinghouse Elec. & Mfg. Co.

**Pittsfield**

November 1—JAPAN, CHINA, AND THE WHITE MAN, by Upton Close.

November 15—AIR CONDITIONING—PERFECT WEATHER IN YOUR HOME 365 DAYS A YEAR.

**Lehigh Valley**

November 18, at Elks Club, Hazleton. THE UNSEEN CONDUCTOR, by Glenn Appleman, Pennsylvania Pwr. & Lt. Co.

**New York**

November 29—Second meeting of the power group: meeting devoted to "Rectifiers and Electronic Devices." C. A. Butcher, Westinghouse Elec. and Mfg. Co., will present "Power Rectifiers" and W. S. Hill, Gen. Elec. Co., will discuss "Power Applications of Electronic Devices." Mercury arc rectifiers, now firmly established in the electric traction field, give promise of becoming practical for low voltage commercial service. Possible application to metropolitan networks will be mentioned. Electronic devices have many present applications and great future possibilities in power and control fields. Distinctions between the various types of tubes together with their applications will be explained. The meeting will convene at 7:30 p.m. and will be adjourned promptly at 9:30 p.m. Non-members are welcome. Discussion is open to all. The location will be Room 1, Fifth Floor, Engineering Societies Building.

## Past Section Meetings

**Birmingham**

Discussion of future plans and reorganization of Section. Election of officers: Howard Duryea, chmn.; H. M. Woodward, secy. Sept. 30. Att. 18.

**Chicago**

Operation of Electrical Machinery in Special Media, by C. J. Fechheimer, consulting engr. Dinner. Sept. 26. Att. 67.

**Cincinnati**

Program Transmission for Broadcasting Stations, by Leo Friedman, American Tel. & Tel. Co. Inspection of the control room in the telephone building. Sept. 22. Att. 112.

**Dallas**

Short talks by B. D. Hull, Southwestern Bell Tel. Co., O. S. Hockaday, Texas Pwr. & Lt. Co., and J. B. Thomas, Texas Elec. Serv. Co. Sept. 19. Att. 50.

**Denver**

Extending Our Frontiers Through Research and Engineering, by H. P. Charlesworth, pres. A.I.E.E., vice-pres. Bell Tel. Labs., Inc. Dinner. Sept. 23. Att. 170.

**Detroit-Ann Arbor**

Hunting Vertebrate Fossils, by Prof. E. C. Case, Univ. of Mich. Dinner. Sept. 20. Att. 68.

**Erie**

Electric Cables, by F. V. Calvert, Gen. Elec. Co. Sept. 20. Att. 25.

**Houston**

The Ultimate Particle, by H. A. Wilson, Rice Institute. Sept. 30. Att. 51.

**Kansas City**

Reports of the summer convention held in Cleveland, Ohio, by A. E. Bettis, Kansas City Pwr. & Lt. Co., R. M. Ryan, Gen. Elec. Co., D. C. Jackson and Robert Warner, both of the University of Kansas. Sept. 26. Att. 65.

**Los Angeles**

Extending Our Frontiers Through Research and Engineering, by H. P. Charlesworth, pres. A.I.E.E., vice-pres. Bell Tel. Labs., Inc. Illustrations. Dinner. Sept. 15. Att. 174.

**Memphis**

Organization and Operation of a Weather Bureau Station, by F. W. Brist, U.S. Weather Bureau Station. Sept. 20. Att. 35.

**Mexico**

Modern Methods of Vertical Transportation, by A. de la Torre, and W. B. Ferguson, Westinghouse Elec. & Mfg. Co. Election of officers: W. A. Schulenburg, chmn.; L. Castro, Jr., secy.; F. Aubert, treas. Sept. 21. Att. 32.

**Montana**

Business meeting. Sept. 16. Att. 12.

**Nebraska**

Prof. M. S. Coover, District Secy., Univ. of Colorado, and Dean O. J. Ferguson, Univ. of Nebraska, spoke on the value of membership in the A.I.E.E. A. L. Turner gave a report of the Summer Convention held in Cleveland, Ohio. Dinner. Sept. 30. Att. 25.

**Niagara Frontier**

Foreign Influences on American Business, by Prof. P. W. Bidwell, Univ. of Buffalo. Dinner. Sept. 16. Att. 55.

**Oklahoma City**

Executive committee meeting. Sept. 2. Att. 11.

Low and Medium Voltage Networks, by Frank Kasper, Byllesby Engg. & Mngt. Corp. Sept. 22. Att. 99.

**Pittsburgh**

The Theory and Operation of the Surge Generator and Cathode Ray Oscillograph, by E. R. Whitehead; Practical Applications and Results Obtained by Use of Surge Generator, by D. B. Perrin. Inspection trip through the laboratories of the Duquesne Light Co. Sept. 20. Att. 220.

**Portland**

Extending Our Frontiers Through Research and Engineering, by H. P. Charlesworth, pres. A.I.E.E., vice-pres. Bell Tel. Labs., Inc. Dinner. Sept. 9. Att. 93.

**Rochester**

Sunlight, by Dr. Brian O'Brien, Univ. of Rochester. Joint meeting with I.R.E. and Rochester Engg. Soc. Oct. 6. Att. 90.

**St. Louis**

Social meeting. Sept. 30. Att. 110.

**San Francisco**

Extending Our Frontiers Through Research and Engineering, by H. P. Charlesworth, pres. A.I.E.E., vice-pres. Bell Tel. Labs., Inc. Sept. 13. Att. 121.

**Saskatchewan**

Recent Developments in Switch Gear, by L. B. Chubbuck, Canadian Westinghouse Co., vice-pres. A.I.E.E. Sept. 7. Att. 27.

Operation of Diesel Engines, by Charles Day, Mirrless Bickerton & Day. Sept. 12. Att. 32.

**Springfield**

Lightning Proof Designs of Transmission Lines, by H. R. Stewart, Westinghouse Elec. & Mfg. Co. Illustrated. Sept. 12. Att. 46.

**Toronto**

The Houses of Life, by Rev. W. J. Johnstone, Eglinton United Church. Sept. 30. Att. 85.

## Past Branch Meetings

**Alabama Polytechnic Institute**

Business meeting. Aug. 29. Att. 20.

The Engineer's Place in the Sun, by Dean W. E. Freeman, Univ. of Kentucky, vice-pres. A.I.E.E. Oct. 6. Att. 31.

**University of Alabama**

Discussion of activities for the coming year. Sept. 26. Att. 20.

**University of Arkansas**

Branch activities were discussed by Prof. W. B. Stelzner, counselor, and L. Wasson, chmn. Sept. 22. Att. 24.

**Bucknell University**

Discussion. Oct. 5. Att. 14.

**University of California**

Power and Economic Basis for Power Transmission, by Prof. W. A. Hillebrand. Film—"A Trip Through the G.E. Plants." Sept. 7. Att. 46.

**Cornell University**

The Organization of the A.I.E.E., by Prof. R. F. Chamberlain; The Early Controversy Between A.C. and D.C. Systems, by Prof. P. M. Lincoln; Photoelectric Cell Applications, by L. F. Moyle, student. Prof. E. M. Strong, counselor, outlined future plans. Oct. 7. Att. 32.

**University of Denver**

Films—"The Electric Ship" and "The Panama Canal." Sept. 27. Att. 20.

**Drexel Institute**

Modern Chain Broadcast Circuits, by J. J. Jaeger, student. Oct. 5. Att. 20.

**University of Florida**

Opportunities in Engineering and How to Prepare for Them, by Prof. Joseph Weil, counselor; Florida as a Come-Back State, by Dean Van Leer. Oct. 3. Att. 90.

**Marquette University**

Board meeting. Sept. 15. Att. 6.

Discussion of proposed constitution. Sept. 22. Att. 13.

Application of Radio to Police Service, by Mr. Wareing, chief engr., Police Radio Broadcasting Dept. Oct. 6. Att. 32.

**Michigan State College**

Business meeting. Oct. 5. Att. 16.

**Mississippi State College**

General discussion. F. G. Marble elected secy. Sept. 22. Att. 27.

**University of Missouri**

Prof. M. P. Weinbach, counselor, outlined the history, purpose, and organization of the A.I.E.E. Raymond L. McGirl elected secy.-treas. Oct. 5. Att. 25.

**Montana State College**

Prof. J. A. Thaler, counselor, outlined the E.E. seminar meetings. R. S. Stokan, chmn., gave a report of the Pacific Coast convention at Vancouver, B.C. R. V. Bauer, student, outlined the purpose and organization of the local Branch. Oct. 6. Att. 101.

**University of Nebraska**

Inspection trip through the power and heating plant of the Lincoln Hotel. Election of officers: John Hutchings, chmn.; Arnold Coffin, vice-chmn.; Charles Devore, secy.-treas. Oct. 5. Att. 22.

**Newark College of Engineering**

Value of Student Societies, by A. R. Cullimore; Branch Activities, by Prof. J. C. Peet, counselor. Sept. 26. Att. 35.

**University of New Mexico**

Election of officers: Stanley O. Fish, chmn., Martin Zirhut, secy.-treas. Oct. 5. Att. 6.

**College of the City of New York**

Business meeting. Sept. 29. Att. 17.

John Ragazzini, chmn., spoke on the advantages of membership in the A.I.E.E. Oct. 6. Att. 34.

**North Carolina State College**

Aims and Purposes of the A.I.E.E., by D. M. House, student; Benefits of the A.I.E.E., by Prof. W. H. Browne, Jr.; Section and District Conventions of A.I.E.E., by Prof. R. S. Fouraker, counselor. Oct. 4. Att. 106.

**University of Notre Dame**

Dr. J. A. Caparo, counselor, outlined the distinction between the local and national benefits of the Institute, and spoke of the advantages afforded by each. Oct. 3. Att. 75.

**Oklahoma A. & M. College**

The Engineering Field in General as Judged From My Experiences, by Prof. J. E. Kirkham. John R. Hollis elected chmn.; Romus Soucek elected vice-chmn. Sept. 19. Att. 26.

**Purdue University**

The Activities and Purpose of the A.I.E.E., by Prof. C. F. Harding; The History of the A.I.E.E. and Its Value to the Student, by Prof. A. N. Topping, counselor; The Indianapolis-Lafayette Section of the A.I.E.E. and the Presenting of Articles to the Branch by Students, by Prof. D. D. Ewing. Sept. 29. Att. 210.

**Rhode Island State College**

Power Distribution in Tall Buildings, by M. Afootian, student. Oct. 5. Att. 20.

**Rose Polytechnic Institute**

Relation of A.I.E.E. to the Student Engineer, by Prof. C. C. Knipmeyer, counselor. Oct. 3. Att. 31.

**Southern Methodist University**

Film—"The Wizardry of Wireless." Oct. 6. Att. 9.

**Virginia Polytechnic Institute**

Flame-Proof Gasoline, by S. L. Butler, student; Electrical Accidents and Their Treatment, by B. G. Belote, student; Niagara-Hudson Power Plant, by H. C. Epperly, student; Electric Machines for Cooling Milk, by B. R. Pogue, student. Oct. 6. Att. 41.

The Great Northern Railway Electrification, by W. P. Swartz, student; Typographs for Bandits, by J. E. Hamm, student; New York City's New Electrical Bank Building, by J. A. M. Maddox, student. Sept. 29. Att. 43.

**State College of Washington**

Dean H. V. Carpenter outlined the proceedings of the annual summer convention held in Cleveland, Ohio. William E. Bratt elected secy. Sept. 30. Att. 15.

**West Virginia University**

Automatic Combustion Control, by C. B. Sims; Direct Reading Ohm-Meter, by G. F. Lefevre; Instrument Transformers, by F. Q. Brown; Use of Electrical Power on Ships, by J. Millard; Air Transportation, by P. M. Vannoy; Electric Service to Morgantown, by L. P. Lovett; History of Michael Faraday, by E. C. McMillan, all students. Sept. 26. Att. 24.

# Employment Notes

## Of the Engineering Societies Employment Service

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## Men Available

### Combustion

PWR. ENGR., mech. and elec., 43, American, college graduate. Past 3 yr. with prominent engg. organization correlating design engg. work for large central station and industrial pwr. plant projects. Previous 4 yr. rebuilding and operating pwr. plant of large eastern copper refinery. Broad experience. D-986.

### Construction

GRAD. E.E., 29, five yr. supervisory construction, design, estimating and field engg. experience on super-pwr. plants, substations; 4 yr. industrial power plant operation. Elec. construction and maintenance experience; [illegible]y. electrification construction experience. C-4428.

### Design and Development

MECH.-ELEC. ENGR., 32, 4 years' Cornell design instructor; 5 yr. Allis-Chalmers design; liberal shop experience; 5 yr. cooperative apprenticeship. Will consider anything, anywhere. Now available. Salary open. D-122.

JUNIOR ENGR., desires employment where high grade technical knowledge is required. Has had laboratory experience. Familiar with elevator service work and elevator parts design. Go anywhere. C-9963.

ELEC. ENGG. GRAD., 28, married, desires position in design and development or teaching. One year Westinghouse student course; 6 months Westinghouse design school; 1½ yr. design of fractional hp. motors; 2½ yr. design of industrial motors. Available at once. Location, U.S. C-5051.

ELEC. ENGR. and designer, 36, married with 20 yr. experience in pwr. and industrial plant operation, design, estimating and planning. Also experience in traction and mining pwr. supply. Last 7 yr. with leading construction engrs. Good references regarding character, personality, cooperative nature, and ability. Permanent position preferred. Salary reasonable. D-1552.

### Executives

ELEC. ENGR., grad., 42, 5 yr. supervision elec. maintenance r.r. Six yr. head elec. and mech. maintenance group 18 coal mines. Eight yr. assoc. editor coal mining magazine, experienced equipment photography, wide acquaintance, numerous excellent references. B-7563.

ELEC. ENGR., E.E. degree. 14 yr. experience public utilities covering valuation work, rate investigations, engg. pwr. plants, substations, transmission lines, including estimates, specifications, design. Experience covers short circuit studies, stability analysis, investigations of systems for load conditions. Desires position, holding company, operating company, or engg. firm. Available immediately. C-9570.

ELEC. ENGR., married, E.E., M.E. 22 yr. experience, designing, construction pwr. plants substations, transmission, distribution systems, and industrial plants. 3 yr. charge purchasing engineering equipment, foreign interests. 3 yr. exec. experience charge engg. department large utility syndicate. English, German, Russian, Armenian, Turkish languages. Available immediately. D-84.

E.E. DEG., 30. Some training in mech. and civil engg., business administration. Sales experience as district representative handling all local sales activities; special sales representative on sales promotion, and technical sales representative. Elec. testing as asst. elec. engr., Underwriter's Laboratories. Also elec. contracting; building construction and specifications experience. Available immediately. D-1344.

ELEC. GRAD., 38, 17 yr. experience, construction, installation, maintenance, inspection, tests, pwr. plant and substations, distribution (high and low tension), one yr. operating, familiar with South America; speaks several languages. Available at once, home or abroad. Best of references. C-2021.

GRAD. E.E., age 31. Ten yr. experience in public utility and industrial work, covering overhead and underground distribution and transmission installations, electrification of industrial plants, standardization of distribution systems. Headed division for study of industrial plant standardization, also research and analysis pertaining to public utility economics. B-6934.

CANADIAN E.E., 28, single. Would take charge servicing and repair shop, Canada or abroad. 8 yr. practical experience all winding and repair work. 3 yr. supervising, estimates, sales engg. Experience in Westinghouse & G.E. service shops. Can handle men. Licensed as e.e. by professional examination Western Canada. C-8336.

TECH. & BUS. ADMIN. GRAD. Lowell Institute School, auspices M.I.T., elec. and mech. courses; B.B.A. deg. from Boston Univ. also grad. work in management. 14 yr. experience operating, elec. design and engg. Desires position with utility or industrial concern. Location in U.S. immaterial. D-1600.

### Inspection

ELEC. GRAD., 38, single, 6 yr. experience factory testing—W. E. & M. Co., East Pittsburgh, Pa. One yr. steel company installing and testing elec. equipment. 6 months' factory inspection of transformers. 2½ yr. general inspection of elec. equipment with insurance company. Good reference. Available immediately. Any location. D-1461.

### Junior Engineers

1932 GRAD., E.E., B.S., Univ. of Maine. Honor student, Tau Beta Pi, Phi Kappa Phi, 23, single, and excellent physical condition. Best of character. Willing to start at bottom and work up. Wage of secondary importance. Location, Eastern States. Available immediately. D-1509.

B.S., M.S., in E.E., cooperative course, M.I.T., 1932; 22 single. Good scholastic record. Short experience at G.E. machine shop on test and res. lab. Aggressive, willing, capable of assuming responsibility. References available. Location, immaterial. Available immediately. Salary secondary. Interested, any position which requires engg. background and which offers a future. D-1511.

JUNIOR ENGR., grad. Pratt Inst., industrial elec. engg., 24, single, 2 yr. maintenance department N. Y. Tel. Co. 0 months' layout and installation heavy elec. equipment. Available immediately. Location, immaterial. D-1471.

B.E.E., Ohio State Univ., 1932, single, 22. Assoc. member of Sigma Xi. High scholastic record and reading knowledge of German. Specialized in communication work, but will consider any engg. work. Location and salary, immaterial. D-1523.

GRAD. E.E., Columbia Univ., 6 yr. course, 1932; single, 24; desires work with utility, railroad, mfg. concern or construction corp. Would like to teach e.e. subjects. Location and salary, immaterial. D-893.

ELEC. ENGG. GRAD. '31. Desires position on land or water (prefer water) as assistant to pwr. plant operator. Employed at present, mfg., heating and ventilating equipment. Available on short notice. References. Location and salary immaterial providing there is a chance for advancement. D-1535.

1931 GRAD., E.E., B.S., leading western univ., 27, single. Telephone work, machine shop apprenticeship, draftsman and machine designer, familiar with vacuum tubes, good mathematician. Excellent scholastic record. English, German, Swedish, Finnish, and Spanish languages. Desires position with industrial firm. Location, immaterial. U.S. or abroad. Available on short notice. D-923.

ELEC. ENGG. GRAD., M.I.T., S.B., S.M., class of '31, age 23, single. 10 months' test and research experience with G.E. Desirous of a position in e.e. field with chance for advancement. Available at once. Location, immaterial. D-1538.

JUNIOR ELEC. ENGR., B.S., 23, grad. specialized course in a-c and d-c motor and generator engg. and testing, invites correspondence leading to permanent connection with established company desiring to develop production, designing, or equipment engr. Would expect shop experience as training for exec. position later. Location, immaterial. D-1543.

B.S. in E.E. in 1932, age 24, single. Experience in mech. engg., elec. engineering, drafting, and design. Prefer exec. type of work but will consider any position with a future. Location in the East. D-1497.

B.S. in E.E., 1932, 24, single. Desires engg. work of any kind. Salary and location secondary. Available immediately. D-1559.

E.E. GRAD., 1929, 25, single, 2½ yr. experience in design and engg. of high tension outdoor and indoor substations. Desires position connected with hydroelectric development. Location desired, South. C-5967.

E.E. GRAD., M.I.T., B.S. 1931, M.S. 1932, 23, single. 16 months' cooperative training with Edison Elec. Illum. Co. of Boston. Temporarily engaged in retail sales of elec. appliances. Desires connection with utility or mfr. leading to a position in the field of engg. management. Location preferred East or Middlewest. D-1565.

E.E. GRAD., 1932, Rensselaer P.I., 22, single. Desires work in any elec. field. Salary and location, immaterial. Available at once. D-1296.

E.E. GRAD., 1932, Northeastern Univ., 22, single, excellent physical condition. Has had 1½

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## ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
San Francisco

205 West Wacker Drive
Chicago

31 West 39th St.
New York

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

**Men Available.**—Brief announcements will be published without charge, repeated only upon specific request and after one month's interval. Names and records remain on file for three months, renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

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yr. experience as cooperative student in experimental lab. of radio condenser concern. Desires position in any field of engg. with opportunity for experience. Location and salary, immaterial. Available immediately. D-1571.

UNIV. OF MICH., 1932 grad. B.S. in E.E., 22, single, excellent physical condition. Best of character and hard worker. Two summers with Mich. Bell Tel. Co. Prefers work in elec. field, but interested in management and personnel work. Location, immaterial. Available immediately. Desires position with future. D-1572.

E.E. GRAD., 1932, Miss. State Col., 22, single. Desires engg. work, but will consider anything. Location, immaterial. Available immediately. D-1570.

M.E.; M.S., 26, single. 4 yr. experience in telephone work. Desires teaching or engg. work of any nature except sales. Available immediately. Location, immaterial. D-1225.

1932 CORNELL GRAD., 22, single. Broad education with major in communications. Good scholastic record. Desires work, preferably on telephone, radio or sound equipment. Location desired East. Salary, immaterial. Available immediately. D-1558.

E.E. GRAD., 1932, M.I.T., M.S., 23, single, one yr. G.E. test. Desires work in elec. machine design and development. Available immediately. D-1579.

B.S. in E.E., 1932, 23, single. Desires position with utility or mfg. concern, preferably in field of radio, power transmission, or elec. ry. engg. Will work at anything if only given a chance to enter an engg. house. Available at once, location and salary, immaterial. D-1546.

M.S. in E.E., '32, B.S., '31; Moore School of Elec. Eng., Univ. of Pa. Grad. work in acoustics, electronics and business admin.; teaching experience and experience in the writing of technical papers for publication. Fluent knowledge of German language. Wants responsible work. Location, immaterial; available on one week's notice. D-1585.

GRAD. 1932, B.S. in E.E., Clarkson Col. Grad. 1929 Rochester Atheneum & Mechanic's Inst., diploma in E.E. 2 yr. factory experience in radio and telephone. Desires to work up. Available immediately. Location, immaterial. D-1583.

E.E. GRAD., 1929, Lehigh Univ., married. Post grade work in business finance and sales. Completed 3 yr. cadet engr. training course of Public Service Elec. & Gas Co., involving work in generation, distribution, commercial and sales departments. Excellent references. Desires position with future. Available immediately. D-1566.

B.S. in E.E., 1932, Purdue Univ., single, 21, desires position in any engg. field. Location, immaterial. Available immediately. D-1588.

E.E. GRAD., Univ. of Minn., 1930, 25, single. 2 yr. experience with large midwest pwr. company, including one yr. training course and one yr. distribution and transmission engg. experience. Available immediately. Location and salary, immaterial. D-1590.

E.E. GRAD., Lehigh U., '31, 24, single. 2 yr. experience elec. const., maintenance, repair in utility field. Thorough knowledge a-c network system of distribution. Majored in elec. traction, elec. design. Special training, writing for trade journals, reports. Will accept offer any field. Location, immaterial, foreign service if possible. Available immediately. D-1540.

B.S. and E.E.,'31, Mich. State Col., G.E. test, 4 yr. practical experience with (manual, supervisory controlled, and automatic) pwr. substations, automatic ry. substations (rotary converter and rectifier) and (frame mounted, cell mounted and metal clad) equipment. Willing to do engg., operating, or teaching. D-1597.

B.S. in E.E., 1930, single, 24. Best references following experience: $1\frac{1}{2}$ yr. construction, operation, steam plants, $1\frac{1}{2}$ yr. industrial sales representative N. Y. corporation, 6 months' westinghouse "central station sales" student work. One yr. elec. maintenance work. Recently night engr., refrigeration and ice mfg. plant. Will go anywhere. Suited to utility. Available. D-1599.

**Research**

ENGR., 28, married, B.S., M.I.T. '30 (honor group), Westinghouse engg. school and design school, 2 yr. experience on solution of special problems, stability studies, transmission lines, experienced in use of symmetrical components, Heaviside's theory and general circuit theory. Available immediately. Location, immaterial. D-1530-329-C-1-San Francisco.

E.E. GRAD., Northeastern Univ., cooperative plan, 1931, B.E.E., 24, single, $3\frac{1}{2}$ yr. experience, research and development on syn. elec. clocks for large elec. clock mfr. in East. Has had general engg. experience pertaining to frequency control installation and design. Desires anything in the field. Location and salary secondary. Available immediately. D-1584.

**Sales**

GRAD. E.E. with 12 yr. sales and advertising experience available. Excellent references from leading mfr. and publisher. Middlewest location preferred. Age 34, married. Strong salesman with excellent contacts in Middlewest. B-8614.

DISTRICT SALES MANAGER OR MFR'S AGENT: experienced engg. representative, desires connection with high grade company that has line of industrial or utility equipment. Eastern location preferred. B-4067.

# Membership

## Recommended for Transfer

The Board of Examiners, at its meeting held September 28, 1932, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the acting national secretary.

**To Grade of Fellow**

Caparo, Jose Angel, head, E. E. Dept., Univ. of Notre Dame, Ind.
Hickok, Robert D., pres., Hickok Elec. Instrument Co., Cleveland, Ohio.

**To Grade of Member**

Anton, George F., asst. prof. in E. E. and physics, Univ. of Porto Rico, Mayaguez, P. R.
Dible, Harvey J., transmission and protection engr., Ohio Bell Tel. Co., Cleveland.
Dow, William G., asst. prof. of E. E., Univ. of Michigan, Ann Arbor.
Edgerton, Harold E., asst. prof. of E. E., Mass. Inst. of Tech., Cambridge.
Lockwood, Earle L., distribution engr., Pub. Serv. Co., Newport News.
MacGregor, Willard H., 217–22 Bayside Blvd., Bayside, L. I.
Milton, Robert M., asst. E. E., U.S. Engr. Office, New Orleans, La.
Noertker, Joseph A., E. E., Cincinnati St. Ry. Co., Ohio.
Pike, Noel, dist. pwr. supt., Guanajuato Pwr. & Elec. Co., Guanajuato, Gto., Mexico.
Reukema, Lester E., assoc. prof. of E. E., Univ. of California, Berkeley.
Schregardus, Dirk, transmission engr., Ohio Bell Tel. Co., Cleveland.
Thomas, Richard N., Borough E. E., Lyttelton, N. Z.
Watson, Malcolm Vau, vice-pres. and genl. mgr., West Coast Pwr. Co.; Calif. Pub. Serv. Co.; Western States Utilities Co., Portland, Ore.

## Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the acting national secretary before Nov. 30, 1932.

Anderson, L. F., Hotel Riviera, 169 Clinton Ave., Newark, N. J.
Benson, I., 57 Ashland Ave., East Orange, N. J.
Bozenschultz, E. J., The Home Tel. & Tel. Co., Ft. Wayne, Ind.
Brandler, A. B., Royal Switchboard Co., N. Y. City.
Cooper, R. E., Jr., Air Corps, U. S. A., March Field, Calif.
Donovan, A. C., Jr., 34 Manchester Rd., Brookline, Mass.
Eash, C. D., (Member), Consumers Pwr. Co., Jackson, Mich.
Erskine, G., Erskine Elec. Wk., Redwood City, Calif.
Foerner, G., 11 a, West End Ave., Bklyn., N. Y.
Forbes, A. F., Newport News Shipbuilding & Dry Dock Co., Va.
Hield, R. F. (Member), Crompton Parkinson, (Canada), Ltd., Montreal.
Kramer, J. E., Kramer Bros., San Francisco, Calif.
Laverty, C. A., Boiler Inspection & Ins. Co., Montreal, P. Q., Canada.
Lee, J. D., Jr., 19 Marine Ave., Bklyn., N. Y.
Martin, H. E. Waterbury Cable Serv., Inc., N. Y. City.
McRae, D. M., Grain Ins. & Guarantee Co., Winnipeg, Manitoba, Can.
Meltvedt, H., (Member), 421 Franklin St., Downers Grove, Ill.
Miller, A. P., 111 Fulton St., Bloomfield, N. J.
Murray, T. E., Jr., (Fellow), Metropolitan Eng. Co. & Metropolitan Device Corp., Brooklyn, N. Y.
Peterson, G. C., 15 Douglas Place, Verona, N. J.
Rosin, A., (Member) Boro. of Richmond, Clove Pumping Sta., Ontario St., Staten Island, N. Y.
Stanley, C. M., Young & Stanley, Inc., Muscatine, Iowa.
St. Laurent, H., Radio Research Lab., Inc., Yonkers, N. Y.
Travis, I., Univ. of Pa., Philadelphia.
Van Sickle, L. R., 416 E. 17th Ave., Denver, Colo.
25 Domestic

### Foreign

Alizo, C., Antonio Cia., Annma., Planta Elec. de Valera, Est. Trujillo, Venezuela, S. A.
Foulsum, W. C., 16 Bondoran Parade, Mont Albert, Melbourne, Australia.
Kesavan, K. V., Pwr. Station, Kottayam Travancore, So. India.
Lautier, V., 37 Sda. San Paolo, Cospicua, Malta.
Rozario, J. F. T., Pub. Wks. Dept., Madras Govt., Madras, India.
Sarda, P. M., Ratan Pole, Nagori Pole, Ahmedabad, India.
Singh, H., Simla Municipal Committee Idgah, Simla, India.
Swami, T. V., Elec. Dept., Cocanada, India.
Tharani, J. J., Elec. Pwr. House Veraval, Kathiawar, Manavadar, India.
9 Foreign

# Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Bohner, C. W., 620—22nd Terrace, Miami, Fla.
Brock, Geo., 1117 N. 15th St., Milwaukee, Wis.
Dalas, F. L., Boulder City, Nev.
Deney, Roger W., 685 Sumner-Atlantic Ave., Forest Hills Boro, Pittsburgh, Pa.
Florez-Estrada, Jose, Avenida De La Paz 60, Reparto Alture-Rio Almendares, Marianao, Havana, Cuba.
Gooding, Chas. C., 1414 K St., Sacramento, Calif.
Jefferson, H. F., 633 Portola Ave., Glendale, Calif.
Keiser, Morris, 1025 King St., Alexandria, Va.
Keller, Dr. Max Leo, Kornweg 8, Aarau, Switzerland.
McShane, Joe B., 810 Western Natl. Bldg., San Antonio, Texas.
Newman, Rexford C., 100 High St., St. Clairaville, Ohio.
Nimetz, John B., 3442 Sacramento St., San Francisco, Calif.
Olsen, V., P. O. Box 404, Shanghai, China.
Peterson, Alex., Central West Pub. Serv. Co., Omaha, Nebr.
Richardson, Jas. Ray, 223 Sheldon Ave., S.E., Grand Rapids, Mich.
Schatz, Nathan, 1845—52nd St., Brooklyn, N.Y.
Shen, C. Mayo, 18 an Check L8, Scott Rd., Shanghai, China.
Thomas, Alfred J., c/o L. J. Healing & Co., Ltd., Yusen Bldg., Tokyo, Japan.
Uline, Wm. A., Northern Elec. Co., Guy & Notre Dame Sts., Montreal, Que., Can.

# Engineering Literature

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

ARCHIV FÜR TECHNISCHES MESSEN. Lieferungen 13–14, July-Aug., 1932. Munich and Berlin, R. Oldenbourg. Illus., 12x9 in., paper, 1.50 rm. each. Section of a comprehensive work which is being published serially on methods of technical measurement and measuring instruments. Each number contains brief articles by specialists; also usually bibliographies. Punched for loose-leaf binder and classified for convenient reference.

CHEMICAL ENCYCLOPAEDIA. By C. T. Kingzett. 5 ed. New York, D. Van Nostrand, 1932. 1014 p., 9x6 in., cloth, $10.00. A convenient one-volume reference work in nontechnical language intended primarily for merchants, manufacturers, and all interested in chemical processes; also useful to professional chemists for rapid reference. A brief, clear account of almost every chemical substance of practical importance.

CHROMIUM PLATING. By E. S. Richards. Phila., J. B. Lippincott, 1932. 131 p., illus., 8x5 in., cloth, $3.50. Intended for those responsible for plating plants and devoted to the practical production of the plate and methods for ensuring regular outputs of good work. Shop equipment and methods of preparing, plating, and finishing work described in detail.

DIESELMOTOREN IN DER ELEKTRIZITÄTSWIRTSCHAFT INSBESONDERE FÜR SPITZENDECKUNG. By M. Gercke. Berlin, Julius Springer, 1932. 92 p., illus., 10x6 in., paper, 6 rm. A study of the suitability of Diesel engines for electric power plants and of the extent to which they have been used. The author gives data upon plants throughout the world, discusses advantages of the Diesel as standby and peak load equipment, and compares its economy with that of steam equipment.

EINFÜHRUNG IN DIE METALLOGRAPHIE. By P. Goerens. 6 ed. Halle (Saale), Wilhelm Knapp, 1932. 392 p., illus., 10x7 in., paper, 15.50 rm.; bound, 17 rm. Since the fifth edition of this book much has been done to clarify the theory of metallography and to extend its practical use. These advances have been used in the revision. A new chapter on the X-ray examination of metals is incorporated. Practical application of metallography in iron testing has been enlarged upon and the advantages of metallographic investigation in studying flaws emphasized.

EINFÜHRUNG IN DIE THEORETISCHE KINEMATIK. By R. Müller. Berlin, J. Springer, 1932. 124 p., 9x6 in., paper, 6.80 rm. This textbook presents the course given by the author at the Darmstadt Tech. Col. It is intended primarily for students of mechanical and electrical engineering, but is adapted also to students of mathematics. Presents theoretical principles underlying machine design, in general purely geometrical.

ELEKTROTECHNICKÁ ROČENKA ESČ 1932. By B. Pařez. Prague, Elektrotechnický Svaz Československý, 1932. 320 p., illus., 12x9 in., cloth, Kc 200. The yearbook of the Czeschoslovak Electrical Society giving a complete description of the condition of the electrical industry in the country, and containing regulations governing electric utilities; very complete statistics upon light and power, radio, telephones, etc.; lists of manufacturers and other data of value to engineers.

ELEMENTS OF PHYSICS. By A. W. Smith. 3 ed. New York & London, McGraw-Hill, 1932. 778 p., illus., 9x6 in., cloth, $3.50. A college textbook giving a survey of the field of physics with considerable emphasis upon modern physics. An endeavor to encourage the student to form physical images of the principles presented and to apply them to the explanation of every-day experiences. Applications of physics to agriculture, engineering, and every-day life are used largely to illustrate the principles.

ENCYCLOPAEDIA OF OXYACETYLENE WELDING. 2 v.; V. 1. Pipe Construction. 83 p. V. 2. Construction of Apparatus and Containers. 80 p. Geneva, Switzerland, International Advisory Committee for Carbide and Welding Technique. (Gift of Acetylene and Welding Consulting Bureau, Ltd., London). 1932. Illus., 12x9 in., cloth, 10s.6d. The first 2 vol. of a series of 6 forming an album on the applications of oxyacetylene welding. Each volume contains about 80 plates of welded structures, and brief explanations in 5 languages. The engineer or manufacturer will find the work interesting and suggestive of many uses for the process.

FEDERAL RADIO COMMISSION, Its History, Activities, and Organization. (Inst. for Government Research, Service Monographs of the U.S. Govt. No. 65.) By L. F. Schmeckebier. Washington, Brookings Institution, 1932. 162 p., 9x6 in., cloth, $1.50. A monograph giving an accurate account of the history and development of the Commission, describing its specific activities in detail and explaining its organization. The regulations governing its work, its appropriations, and expenditures, are presented; with a full bibliography.

HEAT-TREATMENT AND ANNEALING OF ALUMINIUM AND ITS ALLOYS. By N. F. Budgen and D. Hanson. London, Chapman & Hall, Ltd., 1932. 341 p., illus., 10x6 in., cloth, 25s. The theories of hardening and strengthening aluminum alloys, practical methods, and equipment for thermal treatment, its effects upon the physical properties of wrought and cast material, and the annealing of wrought and cast aluminum and its alloys, are discussed comprehensively for the first time. Scattered information is collected and presented for practical use. Dr. Budgen is superintendent of a large English aluminum foundry.

INDEX TO THE LITERATURE OF FOOD INVESTIGATION. V. 4, No. 1, March 1932. London, Gt. Britain, Dept. of Scientific and Industrial Research. 135 p., 10x6 in., paper, 2s. 6d. (Obtainable from the British Library of Information, 270 Madison Ave., New York, $.70.) This index, printed every 6 months, is useful to all those concerned with food production and preservation. Nearly 100 periodicals are covered, entries are classified conveniently, and annotations provided. The engineering section will be found useful as a bibliography of investigations of refrigeration and air conditioning.

INTERIOR AND EXTERIOR LIGHTING. By C. E. Weitz. Scranton, Pa., International Textbook Co., 1931. Pt. 1, Interior Lighting, 41 p.; Pt. 2, Exterior Lighting, 77 p., illus., 8x5 in., cloth, $1.75. A description of modern lighting practise, advising choice of methods and fixtures, standards of illumination for various purposes, and similar matters. A help to those wishing elementary advice in concise form.

INTRODUCTION TO PHYSICAL SCIENCE. By C. W. Miller. New York, John Wiley & Sons, 1932. 403 p., illus., 9x6 in., cloth, $3.00. To provide an elementary text that will offer the necessary fundamental training and at the same time give a broader outlook on modern physics. An effort to lead the student by natural steps from the beginnings of scientific thought to the results of modern research. The text is clear and definite. Mathematics beyond the high school stage are omitted.

LICHTBOGEN - STROMRICHTER FÜR SEHR HOHE SPANNUNGEN UND LEISTUNGEN. By E. Marx. Berlin, J. Springer, 1932. 167 p., illus., 9x6 in., cloth, 18.50 rm. A book to show that it is possible to transform and rectify high voltage currents by means of arcs burning in currents of compressed air. The principles underlying this rectifier and practical methods for constructing arc rectifiers are presented, based largely upon the investigations of Prof. Marx and his colleagues at the Braunschweig Technical High School.

MACRAE'S BLUE BOOK, consolidated with Hendricks' Commercial Register. 40th Annual Edition. Chicago and New York, MacRae's Blue Book Co., 1932–1933. 3333 p., illus., 11x9 in., cloth, $15.00. A buying guide for manufacturers, railroads, mines, municipalities, public utilities, contractors, engineers, and mills. Materials are fully classified and well indexed, with a directory of manufacturers and local distributors, a section describing the trade facilities in towns of more than 1,000 inhabitants, and a directory of trade names. A section is devoted to Canada.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN DES GHH-KONZERNS, Band 2, Heft 2, July 1932. Berlin, VDI-Verlag. 35–56 p., illus., 12x9 in., paper, 2.50 rm. This number gives a description of a new spectrum photometer and its use for the rapid analysis of alloys, especially iron; an article on the resistance of welded bars, a comparison of the calculated resistance of ships with the results of tests on models, and an essay on entropy and probability.

MODERN MATERIALS HANDLING. By S. J. Koshkin. New York, John Wiley & Sons, 1932. 488 p., illus., 9x6 in., cloth, $6.00. A large amount of condensed information in convenient form upon modern methods and equipment for handling materials in factories. Cranes, overhead transporters, trucks, conveyors, hoists, coal, and ash handlers, etc., are considered. Methods of handling different materials and the choice of equipment for any given purpose are discussed.

MODERN PHYSICS. By G. E. M. Jauncey. New York, D. Van Nostrand, 1932. 568 p., illus., 9x6 in., cloth, $4.00. Intended for the student with one year of college physics and mathematics, and directing attention to X-rays, the quantum theory, cosmic rays, relativity, radioactivity, astrophysics, and similar topics. The book is designed to give the student some knowledge of the parts of physics which are now in process of active formation or only recently developed.

NOMOGRAM, the Theory and Practical Construction of Computation Charts. By H. J. Allcock and J. R. Jones. London & New York, Isaac Pitman & Sons, 1932. 209 p., 9x6 in., cloth, $3.00. The authors discuss the general theory of nomograms and give practical directions for making and using all classes of computation charts of scientific or industrial usefulness. The book covers the field satisfactorily and will be welcomed by calculators.

PHOTOCELLS AND THEIR APPLICATION. By V. K. Zworykin and E. D. Wilson. 2 ed. New York, John Wiley & Sons, 1932. 331 p., illus., 8x5 in., cloth, $3. The theory of the photoelectric cell, its manufacture, and its use in picture transmission, television, sound production, and for other industrial purposes, are set forth concisely, yet comprehensively. A book useful to the untrained reader as well as to the specialist. The new edition has been revised thoroughly and 5 new chapters added.

RADIO ENGINEERING. By F. E. Terman. New York & London, McGraw-Hill, 1932. 688 p., illus., 9x6 in., cloth, $5. This textbook aims to present a comprehensive engineering treatment of the more important vacuum tube and radio phenomena for the senior year of an electrical engineering curriculum. The first part of the book is devoted to the theory of tuned circuits, the fundamental properties and the applications of vacuum tubes of importance to all electrical engineers. The second part discusses more specialized radio topics, such as radio receivers and transmitters, wave propagation, antennas and direction finding.

SYMPOSIUM on RUBBER: Cleveland, Ohio, March 9, 1932. Philadelphia, Am. Soc. for Test. Mats., 1932. 160 p., illus., 9x6 in., paper, $1.75.—The papers deal with the manufacture of rubber products and the properties of rubber as an engineering material. Topics discussed include properties of crude and reclaimed rubber, vulcanization, compounding, reinforcing, flexing of rubber products, shock and vibration properties of rubber, deterioration under friction, resistance to water, chemicals and electrical characteristics, and uses as an adhesive.

Die TECHNISCHE ELEKTROLYSE WÄSSERIGER LÖSUNGEN. (Handbuch der technischen Elektrochemie v. 1, 2 pts.) By V. Engelhardt. Leipzig, Akademische Verlagsgesellschaft 1931–32. Pt. 1, 613 p., 52 rm., cloth; Pt. 2, 331 p., 32 rm., cloth, 10x7 in.—With the assistance of German and American specialists, Dr. Engelhardt has undertaken the preparation of a comprehensive, systematic treatise upon the technical uses of electrochemistry and electrometallurgy. This, the first of 5 vols., is devoted to the electrolysis of aqueous solutions. General discussion of theoretical principles and a general review of apparatus (baths, electrodes, diaphragms, etc.) open the volume; then attention is turned to the electrometallurgy of aqueous solutions. The electrolysis of industrial metals is then discussed by various experts. Throughout, attention is concentrated upon present practise, and much note given to descriptions of modern plants, plant and operating costs, and statistics of production and prices. Bibliographies included. Useful to all in search of practical information.

**Engineering Societies Library**

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MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable and an inquiry to the director of the library will bring information concerning them.

# Industrial Notes

**M. P. Ellis Resigns From Steel & Tubes, Inc.**—Announcement has been made by Morgan P. Ellis, of his resignation as general sales manager of Steel & Tubes, Inc., Cleveland, O. Mr. Ellis has not revealed his plans for the future.

**Engineering Firm Opens Cincinnati Office.**—The Burns & McDonnell Engineering Co., consulting engineers, has opened an office at 612 Dixie Terminal Bldg., Cincinnati, in charge of C. F. Lambert, a member of the firm. This company has been established at Kansas City for thirty-five years, and has had an office in Los Angeles for the past ten years. The firm specializes in municipal engineering, including electric light plants, water works, sewer systems, investigations, appraisals, and reports.

**Ball Bearing Sales Consolidation.**—The Marlin-Rockwell Corporation has consolidated the sales activities formerly carried on independently by its subsidiary companies—Gurney Ball Bearing Division, Standard Steel & Bearings, Inc., and Strom Bearings Co. The bearings manufactured by these companies will hereafter be marketed through the corporation's sales organizations, with offices at Jamestown, N. Y., Plainville, Conn., and Chicago. Branch sales offices will be maintained at the former addresses in Detroit, Cincinnati, Cleveland, Los Angeles, and San Francisco. A new branch sales office has been opened at 40 W. 63rd St., New York.

**New York Offices for Amerika-Interessen, Inc.**—Offices have been opened in the Chrysler Building, New York, by Amerika-Interessen, Inc., organized as the American unit of A. G. Fuer Amerika-Interessen, operating also in Berlin, Paris, and London. According to Botho Bilienthal, president, in order to surmount tariff barriers, the corporation plans to make available to the manufacturers of one country such devices, processes and patents that have been proved successful in other countries. For manufacturers who wish to augment their incomes by obtaining business abroad, but cannot do so by exports, agreements are negotiated covering production and marketing rights. This is done by issuing licenses on a royalty basis or by the outright sale of the manufacturing and marketing rights for the country involved. The American company's engineers have selected from over 1,000 offerings, about 100 devices that seem suitable for immediate exploitation in this country. These are in many fields and include such widely different lines as machine tools and appliances, electrical devices, temperature indicators and recorders, optical instruments, advertising displays, air conditioning equipment, welding processes, steel house construction, etc.

**Splash-Proof Motor.**—The Louis Allis Co., Milwaukee, has introduced a splash-proof motor safeguarded to prevent entrance of water splashed with terrific pressure from any angle, yet adequately ventilated and built in the same dimensions as a standard open motor. A double baffle in an elliptical-shaped air passage in each end-bell provides the unusual protection offered by this new motor. The unique construction permits free passage of ventilating air yet traps and drains water splashed into the air openings at the bottom of the elliptical-shaped chambers. Another original feature is a shaft guard which breaks the force of a stream directed along the shaft extension and prevents water from entering the bearing chamber.

**New Circuit Breaker.**—The Delta-Star Electric Co., Chicago, announces a new 5 kv, 3,000 amp, 50,000 kva three-pole, non-oil throwing type, indoor oil circuit breaker. The welded square tank with full rounded corners, is fabricated of heavy steel plate, thoroughly reinforced and banded. The interior is completely lined with arc-resisting material. The straight line motion mechanism, composed of non-magnetic steel parts, operates under a heavy, Everdur domed tank head, eliminating magnetic heating. The terminals and bushings are made of copper bars with wrapped, impregnated, bakelized paper. These terminals are held to the domed head by means of non-ferrous clamps. The breaker lift rods travel through roller guides, insuring positive alignment with low friction losses, and high speed of contact operation.

**Another Burndy Lug.**—Continuing on a program of developing connectors for wires and cables based on the clamp type principle, the Burndy Engineering Co., Inc., New York, has developed a clamp type lug that possesses new features which minimize installation costs. To install the new type of Burndy lug requires only a wrench and a minute or two of time. The compression principle used provides contact over a large cable area in close intimacy with the contact tongue of the lug. Designs of the new device for all standard wire and cable sizes, as well as odd combinations of angle connections for single and multiple conductors have been prepared. Since its introduction there have been a number of notable installations, including the use of thousands of the lugs in the Rockefeller Center group of buildings in New York.

**New Electrostatic Voltmeters.**—A complete line of electrostatic voltmeters, designed to provide a ready means for measurement of high d-c and a-c voltages, particularly in circuits of high resistance where any appreciable current taken by a voltmeter introduces considerable error, has been developed by Ferranti, Inc. The instrument is entirely free from wave form, frequency and temperature errors, and is available in the single range projecting, flush or portable types, fitted in $2^1/_2''$ moulded bakelite cases. The meter can be supplied in nine different ranges having full scales from 450 volts to 3,500 volts, the capacity ranging from 30 micro-microfarads with full scale deflection for the 450-volt meter, to 5 micro-microfarads for the 3,500-volt instrument. The meter is designed with an 80° scale readable to the unusually low figure of 20% of the full scale value.

A safety resistance of high value is fitted inside the case of each instrument to limit the current in the event of a flash-over due to over-voltage. This resistance renders the meter free from damage to over-load provided that the over-load is maintained for only a short time. The Ferranti electrostatic voltmeter is essentially a variable condenser, and although there is a minute current passed by the instrument on alternating current circuits, there is no power loss as the current is 90° leading with respect to the voltage and has no "in-phase" component. The instruments are magnetically damped, and have reasonably high torque for this class of meter.

# Trade Literature

**Uses of Hard Rubber in Industry.**—Catalog 1, 18 pp. Describes hard rubber products for industrial purposes. Illustrations include applications in electrical manufacturing. American Hard Rubber Co., 11 Mercer St., New York.

**Midget Motors.**—Bulletin, 4 pp. Describes "Barcol Midget" shaded pole induction motors. Other bulletins on two-pole and four-pole undirectional motors and two-pole geared-head, and reversing motors, 1–100 hp and less, are also available. Barber-Colman Co., Rockford, Ill.

**Constant-Tension Drive.**—Bulletin 602, 4 pp. Describes the Reliance automatic tension regulator for application to any process requiring a constant tension in material being wound or unwound from a reel. Reliance Electric & Engg. Co., 1088 Ivanhoe Rd., Cleveland, O.

**New Metering System.**—Bulletin 1960, 8 pp. Describes a new metering system combining the advantages of the new OC detachable watthour meter, the new portable stroboscopic standard, and the nofuse load center. Each of these pieces of equipment is illustrated and its use in the system explained. The field testing method provided by the stroboscopic standard constitutes a new element in metering. Westinghouse Elec. & Mfg. Co., Newark, N. J.

**Ratchet Type Relay.**—Bulletin CX 464. Describes the "Dunco" ratchet type, or sequence relay. The energizing of the coil moves the pawl, engaging a ratchet which actuates a cam or cams to open or close the contacts. By a minor adjustment of the cams moving the contacts together, these relays can be made single pole, double break; double pole, single break; or single pole, single break, double throw. Relays can be furnished for various voltages, alternating or direct current. Struthers Dunn, Inc., 139 No. Juniper St., Philadelphia, Pa.

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### Front Cover

An electric passenger train leaving the west end of the famous Cascade tunnel on the Great Northern Railway in Washington. The tunnel is 7.79 miles long and cost $14,000,000 to build; it was completed early in 1929. The locomotive is of the single-phase motor-generator type operating on 11,000 volts, and weighs 260 tons.

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**Officers and Committees** (For complete listing see p. 678–81, September 1932 issue of ELECTRICAL ENGINEERING.)

PULP insulation may now be applied directly to the conductor of a telephone cable, the paper making and insulating operations being combined into one process. A considerable saving over spirally wrapped paper insulation is made possible by the use of a low cost Kraft pulp and the elimination of the paper making, paper splitting, and handling operations. *p. 838–43*

DISCUSSIONS of the technical papers presented at the Institute's Middle Eastern District meeting, Baltimore, Md., October 10–13, 1932, have been reviewed and summarized. *p. 877–9*

UNLIMITED range is available in a new electrostatic voltmeter for measuring either a-c or d-c potentials. It is a rugged and portable instrument, has high accuracy, short period, linear scale characteristics, and draws no current. *p. 863–5*

LIGHTNING protection has been carefully considered in the design of the Safe Harbor-Westport 230-kv transmission line. Insulation is particularly heavy, ground wire protection has been applied according to the latest theory, and special effort has been made to reduce tower to ground resistances. *p. 834–8*

SYNCHRONOUS motors applied to constant speed main-rolls in metal rolling mills, both steel and non-ferrous, are rapidly increasing in favor, due to improvements in the synchronous motor and its control, and the favorable first cost. *p. 855–8*

FAULT location on power cables has been facilitated by one company through the use of constant current transformer for reducing high initial fault resistance, and a short circuiting switch for generating signals which locate the fault. *p. 870–2*

QUICK stopping of synchronous machines usually can be accomplished most satisfactorily by dynamic braking. Accurate prediction of the number of revolutions and time required to stop now can be made by means of simple formulas. Changes in excitation during the stopping period are taken into account. *p. 843–5*

ECONOMIC aspects of water power have been analyzed to facilitate comparison between hydroelectric and steam plants. The capacity and energy costs of hydroelectric power are expressed in terms of the cost of steam power, and various factors affecting any decision as to whether a hydroelectric or steam power plant is to be built are discussed. *p. 849–52*

METAL transfer during electric arc welding, although subjected to much discussion, is not fully understood. The mechanism of this transfer has been studied by a new method which it is stated records all of the possible forms of metal transfer, by means of a metallic strip moving at high speed through the arc. This method indicates that liquid globules are the chief form of metal transfer. *p. 852–4*

CHANGES have been made in the prizes which the Institute presents for technical papers. These changes concern the prizes for national, Section, and Branch papers. Although the cash awards have in some cases been eliminated, ample incentive for the preparation of well written papers should remain. *p. 875*

TECHNICAL papers to be presented at the 13 sessions of the Institute's coming winter convention to be held in New York, N. Y., January 23–27, 1933, have been tentatively arranged. The subject balance of these papers is particularly good, and should draw many to attend the convention. *p. 873–4*

ACTIVITIES in unemployment relief during the winter 1931–32 were summarized in ELECTRICAL ENGINEERING for November 1932, p. 809–13. Supplementing this article, suggestions which have been received from many Sections of the Institute, giving methods which may be followed during the coming winter, are presented in the present issue. *p. 880–2*

HOUSE telephone cables for large buildings require consideration of many factors to insure that the telephone plant shall be used with the maximum degree of efficiency. *p. 867–9*

# Recommended Practises for the Protection of Electrical Apparatus

**The relay subcommittee of the A.I.E.E. protective devices committee herewith submits its recommendations for the protection of electrical apparatus. These recommendations are based upon a questionnaire and the 37 replies thereto from specialists in this field. Answers were interpreted and codified by a group of 20 experienced engineers particularly interested in the protection of electrical apparatus and circuits. It is hoped that this concensus of present-day opinion will be the beginning of a series that will be augmented and improved with each periodic analysis and reissue.**

IN THE PAST, 3 papers entitled "Transmission Line Relay Protection" have been presented before the Institute. These indicated the progress of the protection art and discussed in some detail certain methods considered general practise at the time they were written. The last one, presented in 1930, contained brief notes on the protection of some of the major items of system equipment. At that time, however, it was believed desirable to have a similar paper prepared, which would be devoted to apparatus protection. It is therefore the purpose of this report to present a review of those methods that are in general favor at the present time, and that are considered good practise for the protection of the main items of electrical apparatus.

Information upon which this report is based was furnished by representative engineers associated with protective problems in public utility and industrial fields. In order that the survey might be as comprehensive as possible, 61 copies of a questionnaire were distributed, of which 35 were returned. To guard against answers being given in the light of past practise the transmittal letter emphasized particularly the value of opinions based upon future applications rather than upon existing installations. Therefore it may be assumed confidently that the condensed results given express the most advanced ideas of a preponderant body of engineers engaged directly in the study of protection problems.

In but few cases the average opinion expressed in the questionnaires differs from the views of the committee. Where such disagreements occur, both opinions are given, together with the reasons that influenced the committee in qualifying the average opinion disclosed by the questionnaire. While agreement was not always unanimous, no radically different views were found to exist.

There appears to be a growing recognition of the importance of considering protection problems from 2 major viewpoints: (1) their monetary significance as insurance against damage to equipment, and (2) the less tangible, but no less vital relation they bear to the value of the service in terms of good-will. The former may be computed readily from existing records of repair costs; the latter is more difficult to evaluate in a pecuniary sense and consequently is susceptible to a variety of conclusions when considered from the angle of return on capital invested. It is not disputed that this return is large, especially in comparison with the cost of the protective devices, and that it probably will loom still larger as power system growth and interconnections continue.

In arriving at the opinions expressed the committee duly weighed the cost of the protective equipment against the value of the results to be expected. This procedure will be found borne out by the kilovolt-ampere ratings for which the more expensive methods of protection are recommended. Not only is a large piece of apparatus inherently more costly than a small one, but its incapacity to operate will result in relatively greater inconvenience to the system it serves.

It should be remembered also that these recommended ratings apply to the general case and that special situations will arise in which it may be

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Full text of a report (A.I.E.E. Paper No. 33-1) prepared by the relay subcommittee of the protective devices committee to be presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 23–27, 1933.

Members of relay subcommittee—O. C. Traver, *chairman*, Genl. Elec. Co., Phila., Pa.; E. H. Bancker, Genl. Elec. Co., Schenectady, N. Y.; D. L. Bement, Northern Ind. Pub. Serv. Co., Hammond, Ind.; H. D. Braley, N. Y. Edison Co., New York, N. Y.; R. E. Cordray, Genl. Elec. Co., Phila., Pa.; G. B. Dodds, Duquesne Lt. Co., Pittsburgh, Pa.; W. W. Edson, Edison Elec. Illum. Co., Boston, Mass.; L. E. Frost, Bklyn. Edison Co., Bklyn., N. Y.; D. E. George, Tenn. Elec. Pwr. Co., Chattanooga, Tenn.; S. L. Goldsborough, Westinghouse E. & M. Co., Newark, N. J.; W. A. Lewis, Westinghouse E. & M. Co., Pittsburgh, Pa.; H. A. McLaughlin, Central Hudson Gas & Elec. Co., Poughkeepsie, N. Y.; J. H. Neher, Phila. Elec. Co., Phila., Pa.; R. E. Pierce, Elec. Bond & Share Co., New York, N. Y.; C. F. Powers, New England Pwr. Corp., Boston, Mass.; H. M. Rankin, Metropolitan Edison Co., Reading, Pa.; A. W. Rauth, Consumers Pwr. Co., Jackson, Mich.; F. O. Schnure, Bethlehem Steel Co., Sparrows Point, Md.; H. P. Sleeper, Pub. Serv. Elec. & Gas Co., Newark, N. J.; E. R. Stauffacher, So. Calif. Edison Co., Los Angeles, Calif.; George Steeb, Buffalo Niagara & Eastern Pwr. Corp., Buffalo, N. Y.; and E. M. Wood, Hydro Elec. Pwr. Comm., Toronto, Canada.

Others who supplied data through their replies to the questionnaire—T. J. Bostwick, Aluminum Corp. of America, Pittsburgh, Pa.; E. A. Childerhose, Stone & Webster Co., Boston, Mass.; H. W. Collins, Detroit Edison Co., Detroit, Mich.; L. E. Cook, Texas Pwr. & Lt. Co., Dallas, Tex.; A. C. Cummins, Carnegie Steel Co., Duquesne, Pa.; C. H. Frier, Okla. Gas Co., Okla. City, Okla.; G. W. Gerrell, Union Elec. Lt. & Pwr. Co., St. Louis, Mo.; A. S. Goodrich, Hammermill Paper Co., Erie, Pa.; H. H. Green, Pa. Pwr. & Lt. Co., Hazleton, Pa.; J. Hellenthal, Puget Sound Pwr. & Lt. Co., Seattle, Wash.; A. V. Joslin, Pacific Gas & Elec. Co., San Francisco, Calif.; J. T. Logan, Georgia Pwr. Co., Atlanta, Ga.; C. A. Muller, American Gas & Elec. Co., New York, N. Y.; P. H. Robinson, Houston Ltg. Co., Houston, Tex.; J. J. Samson, Commonwealth Edison Co., Chicago, Ill.; C. J. Smith, Illinois Steel Co., Chicago, Ill.; and E. B. Wagner, Lehigh Valley Coal Co., Wilkes-Barre, Pa.

deemed advisable either to raise or to lower them. Machines of a certain rating may seem small on a large system and yet attain considerable importance when the system to which they are attached is itself small. In view of the difficulty of basing recommended ratings upon the size of the system the committee felt that it was preferable to consider such ratings upon the more definite basis of intrinsic values and relative costs of protection.

This report deals particularly with protection against electrical and mechanical failure. When applied to unattended apparatus it overlaps to some extent the field of A.I.E.E. STANDARDS NO. 26 on automatic stations which embrace protection against control failure.

## A-C GENERATORS

*Differential Protection.* In general differential protection is recommended for a-c generators. Equipment used for this protection should disconnect the line and field simultaneously and also the neutral if an adequate circuit breaker is provided. In some cases it shuts down the prime mover. This equipment also should prevent any dangerous rise of exciter voltage when the exciter is connected directly to a hydroelectric generator, or in any other situation in which the exciter may attain excessive speed upon loss of load on the prime mover. As a further precaution against the spread of destructive effects following an internal failure, the differential relay may be utilized to liberate carbon dioxide within the shell of any machine that has a degree of enclosure sufficient to render the gas effective.

For generators of either the open or enclosed type at attended stations differential protection is recommended for ratings of 1,000 kva and higher. The average, as derived from answers to the questionnaire, is 3,000 kva; but in view of the intrinsic value and the good results on record the committee felt justified in lowering this figure. At unattended stations differential protection is recommended for generators rated at 250 kva and higher.

From the standpoint of service, frequently a small generator may be as important as a larger one; this is especially true where a small machine is operating directly on a bus with larger generators which already are provided with differential protection. In such case a fault in the small generator, if not quickly removed, may prove as embarrassing to the service as a similar fault in a large generator; hence here differential protection for the small machine is strongly indicated.

In view of the decreased hazard of insulation failure at low voltages this form of protection is recommended only on machines rated at 2,300 volts and higher. This opinion is strengthened by the high currents usually encountered at lower voltages, since these require rather massive terminals and involve greater difficulty in bringing out all of the necessary armature leads.

It is recommended that the zone protected by the differential relay include as far as possible all conductors that extend from the generator armature to the bus and the circuit breaker as well.

On generators of 20,000 kva or larger, having 2 or more parallel windings per phase and where there is a possibility of turn-to-turn failure, it is recommended that additional protection be provided in the form of a differential relay actuated by a difference of in-phase currents that may occur in the parallel windings. When the neutral is solidly grounded a turn-to-turn fault will develop quickly into a fault to ground; therefore this protection is recommended particularly in cases where the generator neutral is not solidly grounded. The possibility of circulating currents also must be investigated when parallel balance is contemplated; perhaps, however, these can be avoided when the machine is designed. Unless this precaution is taken it is possible that on external faults circulating currents may cause improper operation of the relay. With some types of armature windings this relay also is capable of detecting short-circuited turns in the field winding. Since this form of protection is recommended only for large machines its provision adds but a small fraction to the over-all cost of the unit.

*Overcurrent Protection.* The use of overcurrent protection for generators in attended stations is not regarded favorably, but is recommended for back-up protection at unattended stations. When generators at attended or unattended stations are not provided with differential protection, then overcurrent devices, actuated either directly by the armature current or by its thermal effect as in a replica relay, should be employed. However, because of the rapid decrement of the short-circuit current, care must be exercised in the use of overcurrent relays.

A replica relay operates at a specific temperature of its own mechanism which is designed to have at all times the same temperature as the device protected, when subjected to the same ambient conditions. Other types of temperature relays function on the actual temperature of the machine as determined by elements in direct contact, such as embedded temperature coils or thermocouples. Temperature relays are regarded as a valuable guide to the operator. It is the general opinion that in attended stations they should not disconnect the machine, but should provide only a warning signal.

*Field Temperature Protection.* In general field temperature protection is not recommended. An exception, however, is made in favor of its application to generators that are provided with high speed excitation and paralleled over long transmission lines. Under short-circuit conditions a heavy field is applied quickly to hold these generators in step; if this field current is not reduced within a reasonable time it is possible for the generator field to overheat without the knowledge of the operator. To guard against this contingency a field temperature relay may be provided to sound an alarm in attended stations and to shut down the overheated machine if the station is unattended.

*Power-Directional Protection With Time Delay.* In the past this combination of protective devices occasionally has been used to prevent motoring on the part of a steam-turbine-driven generator. Since the purpose which it served now can be taken care of automatically at the throttle, it is the general opinion that, except perhaps in rare cases, the need for this form of protection no longer exists. Its use as a protective measure against internal insulation failure is not recommended and can be justified only in the case of old machines which are not provided with sufficient armature terminals for the application of differential protection.

*Bearings.* Temperature protection is recommended for the main bearings of all unattended machines.

*Protection Against Overspeed.* It is agreed that the usual provision at the prime mover for protection against overspeed is satisfactory for the purpose and that nothing further should be necessary.

*Protection Against Accidental Loss of Field.* Protection against loss of field is recommended for disconnection of the generator at unattended stations. A d-c undercurrent relay is the logical device for this purpose, but it must be given a suitable time delay to prevent its operation during transients reflected from the armature under short-circuit conditions. In attended stations this type of protection seldom is used; where it is used the relay should not disconnect the generator but may provide an indication to the operator upon the occurrence of this condition.

### FREQUENCY CONVERTERS; SYNCHRONOUS CONDENSERS

Recommendations regarding protective equipment for a-c generators apply also to frequency converters and synchronous condensers. In addition it is believed that some provision (usually time overcurrent relays) should be made for disconnecting a frequency converter under out-of-step conditions. Usually it is advisable to provide also time-delayed under-voltage protection for synchronous condensers. No distinction is made between attended and unattended stations in the use of these additional features.

### D-C GENERATORS

At attended stations protection against overcurrent is considered necessary for d-c generators and, in addition, when these machines operate in parallel with another source of power, provision should be made for protection against reversal of the normal direction of current flow, functioning independently. Additional refinements are usually necessary in unattended stations, but the variety and special nature of these devices do not permit of their inclusion in a general condensed report. They may be found listed in A.I.E.E. STANDARDS NO. 26.

*Bearings.* Temperature protection is recommended for the main bearings of all unattended machines.

*Exciters.* When exciters are direct-connected and do not operate in parallel, it is recommended that no protection against electrical failure be used. For parallel operation, protection against overcurrent in a reverse direction should be provided. The current setting should be high enough to prevent possible disconnection of the machines when paralleling and when momentary disturbances are reflected from the a-c generator armature during a-c short circuits.

### POWER TRANSFORMERS AND POWER AUTO-TRANSFORMERS

*Differential Percentage.* When circuit breakers are provided for each winding, percentage differential protection is recommended for 2- or 3-winding power transformers of 1,000-kva rating and higher, either with or without tap-changing equipment, and whether operated singly or in parallel. As disclosed by the questionnaire the average minimum rating for which differential protection is recommended was found to be 5,000 kva. The committee recommends that differential protection always be provided for banks of 5,000 kva and more if operated in parallel, even though additional breakers must be purchased. When the transformer bank is part of a line and is provided with a circuit breaker on the bus side only, certain modifications of the foregoing method are recommended. These will be found under a subsequent heading.

When the necessary circuit breakers are provided for complete isolation of a power auto-transformer, percentage differential protection is recommended for an equivalent physical capacity of 1,000 kva and greater. It is recommended also that all banks of power auto-transformers operated in parallel of an equivalent physical capacity of 5,000 kva and greater be provided with differential protection even though additional breakers must be purchased. The auto-transformer output rating corresponding to 1,000 or 5,000 kva of equivalent physical capacity will vary, of course, with the ratio of voltage transformation. In general the ratio of the equivalent physical capacity of an auto-transformer to its output is equal to the per cent voltage transformation, based upon the high voltage thus:

$$\frac{\text{Equivalent capacity}}{\text{Rated output}} = \frac{E_1 - E_2}{E_1} = 1 - \frac{E_2}{E_1}$$

where $E_1$ is the high voltage, and $E_2$ the low voltage.

It is recommended that circuits embraced by the differential protection include all conductors up to and including the circuit breakers on each side of the transformer.

*Overcurrent Percentage (Differentially-Connected).* When differentially-connected overcurrent relays are used in place of percentage differential protection for any of the foregoing types of transformers, it is recommended that they be of the inverse time type. This time characteristic prevents operation on external faults which otherwise may create sufficient unbalance at the relay to bring about needless tripping.

*Back-Up Protection.* In addition to differential protection, overcurrent or other back-up protection (not necessarily at the transformer itself) should be provided at some point on the source side to protect the transformer against the effects of sustained excess currents which may arise from failure of protective apparatus to clear faulty equipment. Temperature relays, either operated by embedded coils or of the replica type (described under "A-C Generator Over-Current Protection"), also occasionally are employed. When a transformer is not protected by differential methods it is recommended that overcurrent protection always be provided.

*Smoke or Gas Detectors.* Insufficient experience with these devices in the United States precludes the expression of an opinion regarding their value, or their possibilities, as a means of transformer protection.

*Transformers Having Breakers Only in the Low Side.* Power transformers that have a circuit breaker on the bus side only, the other side being connected directly to the line, generally are treated as part of the line and consequently included in the line protection. When the latter is protected by distance or directional overcurrent relays it is suggested that differential protection also be considered for the power transformer and that this protection be arranged to trip the transformer breaker. Under some circumstances this will result in speedier isolation of the disturbance. For example, if a fault occurs in the transformer during a period when normal power is flowing from the bus toward the far end of the line, the directional relay at the distant end cannot respond to the fault current until it has grown to proportions sufficient to overcome the torque produced by the normal direction of power. By quickly tripping the bus breaker, however, the differential relay interrupts the normal flow of power and thus frees the distant directional relay of its normal power torque. The directional relay then responds to the feeble fault current and the transformer is isolated before serious damage can result.

*Magnetizing Transients.* Replies to the questionnaire disclose that trouble from magnetizing transients is of sufficiently frequent occurrence to warrant some statement by the committee regarding means for overcoming its effect on the protective relays. Inrush magnetizing currents disturb the balance at the differential relay, and may cause needless tripping of the breakers. The ability of power sources of large capacity to maintain full voltage at the inception of the transient adds greatly to the magnitude which it may attain. These abnormal currents are caused primarily by the residual magnetic flux; should this be of appreciable magnitude, and in a direction such that the flux change required by the voltage at the moment of switch closure will push the total flux above the knee of the saturation curve, it follows that the magnetizing current will be unduly large. The difficulty is more pronounced on 25-cycle systems.

Special or additional equipment is available for preventing tripping during the magnetizing transient and this precaution is always necessary when high speed relays are used. The more common types of relays, however, being slower, usually will ride safely through the transient; where such relays are employed the committee believes that the addition of the special equipment referred to should be based more properly upon the trouble which the user encounters.

It is pointed out also that undesired operation of differential relays may occur at the moment of clearing an external fault originating in the vicinity of the transformer. Just before the fault is cleared the voltage at the transformer may have fallen to 0 and immediately afterward will tend to return to normal, thus simulating on a smaller scale the conditions obtaining at initial magnetization. Experience with trouble arising from this cause having been meager, the committee does not feel called upon to suggest measures for its avoidance.

## A-C MOTORS

An analysis of the replies to the questionnaire indicates a general agreement on the desirability of differential protection for large a-c motors, the average minimum rating at which it should be applied being 1,750 hp. It was the opinion of the committee that motors of 2,000 hp and more, with a minimum rating of 2,200 volts, should be provided with differential protection.

*Overcurrent Protection.* In addition to differential protection, temperature relays, either of the replica type or operated by embedded coils, are recommended for protection against excessive or prolonged overloads. Due to loss of cooling by windage the latter will represent more accurately the true motor temperature under stalled-rotor conditions.

For motors of less than 2,000-hp rating where differential protection is not employed inverse time overcurrent and instantaneous overcurrent protection is recommended, the instantaneous relay being set for currents greater than the stalled-rotor current to take care of severe short circuits only.

*Undervoltage Protection.* When undervoltage protection is used it should have sufficient *time delay* to enable the motor to coast through temporary dips in voltage. Undervoltage protection is not recommended for motors that start on full voltage since these will come up to speed automatically when normal voltage is resumed.

*Phase-Rotation Protection.* Relays to guard against reversal of phase-rotation are recommended chiefly for use at unattended stations and in elevator service.

*Protection Against Unbalanced Phase Currents.* Dielectric failure results in unbalanced phase currents and negative phase-sequence components. This condition may be detected by a relay which is actuated either by the unbalanced phase currents themselves or by their corresponding negative phase-sequence components. When differential protection is not possible or practicable these relays frequently are used at unattended stations; but it should be remembered that phase-balancing action will produce unbalanced conditions in sound motors and thus may lead to erroneous tripping of circuit breakers on the occasion of an external unbalanced fault.

*Bearings.* Temperature protection is recommended for the main bearings of all unattended machines.

*Power Station Essential Auxiliary Motors.* It is important that motors driving essential power station auxiliaries not be removed from service except as a last resort and then, in the interest of service, their isolation should be accomplished as promptly as possible. For this reason it is recommended that such motors be protected by instantaneous overcurrent relays set for currents considerably greater than the stalled-rotor current. When temperature relays are used in connection with these motors they should be arranged to sound an alarm only. Phase-balance relays or negative phase-sequence relays are not recommended for essential motors because of the phase-balancing tendency of polyphase motors mentioned in the second preceding paragraph.

It is not common practise to ground the neutral of the supply source for essential motors, but if for any reason such a condition exists, ground relays advantageously may be added to the protection.

### D-C Motors

Fuses are considered sufficient protection for small d-c motors. For medium and large sizes overcurrent and undervoltage protection, usually self-contained in the air circuit breaker itself, are recommended. Where the machine is very large, and its service correspondingly important, additional refinement in the form of temperature protection is desirable.

*Bearings.* Temperature protection is recommended for the main bearings of all unattended machines.

### Synchronous Converters

Synchronous converters require protection on both the a-c and the d-c sides. On the a-c side inverse-time overcurrent protection is recommended to trip the oil circuit breaker. In addition, when the d-c side is grounded and flashover possible, an instantaneous flashover relay, connected between the machine frame and ground, is recommended to disconnect both the a-c and d-c sides. If the possibility of flashover exists, and no flashover relay is provided, it is recommended that the overcurrent protection on the a-c side be instantaneous instead of inverse time. For the d-c side instantaneous overcurrent protection is recommended, and in addition, when the machines are operated in parallel, separate reverse current protection should be provided to disconnect the converter when power flows toward it from the d-c bus. Most synchronous converters are equipped with mechanical overspeed devices; these should trip the d-c circuit breaker and, if the system is subject to runaway speeds, the a-c circuit breaker also. Additional information will be found listed in the A.I.E.E. Standards No. 26 on Automatic Stations.

*Bearings.* Temperature protection is recommended for the main bearings of all unattended machines.

### Rectifiers

Rectifiers are almost universally automatic in their operation. It is believed that recommendations for their protection are covered adequately by the tabulation given in A.I.E.E. Standards No. 26 on automatic stations.

### Bus Protection

*Differential.* All failures occurring on important buses should be promptly isolated. Differential methods which balance all currents entering and leaving the bus are recommended for this purpose. In such applications it is important that the ratio characteristics of the current transformers in the differential circuit should hold substantially within the relay setting at the maximum primary currents so that incorrect operation cannot occur on external faults. With a given core design the higher the transformation ratio the more accurate is the ratio curve. Desired conditions can be achieved best by the use of a single ratio for all current transformers taking part in the differential scheme. If it is not possible to follow this recommendation and current transformers of different ratios are employed, then auxiliary current transformers must be used in the secondary circuits to equalize the different ratios at the balance point.

It should be noted, however, that when an auxiliary transformer is used to increase the ratio of a low-ratio line current transformer, a double handicap is placed upon the equipment compared to that which would result from the use of a single current transformer having the same total ratio. This follows because: (1) In the lower-ratio transformer ratio-error begins at lower currents; and (2) the additional burden imposed by the auxiliary transformer also has the effect of increasing the ratio-error in the line current transformer.

Under certain conditions of power feed restraint may be used advantageously in the differential relay. In general, however, these conditions do not obtain and the effect of restraint if used cannot be predicted with any degree of certainty.

*Ground Fault Bus.* When the system is grounded a ground fault bus may be used, each protective relay being operated by a current transformer inserted in the common ground connection for its particular bus section. If provision be made for the application of this method during the station design period, its installation does not involve the serious constructional difficulties that may be encountered in attempting to introduce it in an existing station.

### Grounding Equipment

*Grounding Resistors and Reactors.* It is recommended that grounding resistors and reactors be protected by overcurrent or temperature relays which, after a short delay sufficient to allow line protection to function, will initiate an alarm to indicate that a ground fault has not been cleared properly. This procedure is designed to give the operator an opportunity to carry out a course of action already decided upon for such conditions.

Fortunately the trend toward the use of resistors having a 2-min ground fault capacity allows reasonable time for disconnecting the source of trouble without opening or short-circuiting the resistor. Should either of these latter courses become necessary, however, it would seem preferable from a protection standpoint to maintain the system ground by short-circuiting the resistor, unless this action nullifies the purpose, such as prevention of telephone interference, for which the resistor originally was installed.

*Grounding Transformers.* Protection for grounding transformers of either the zig-zag or Y-Δ type should follow substantially along the lines indicated for grounding resistors and reactors in so far as the effects of sustained external ground faults are concerned.

For protection against internal faults 2 forms of differential protection may be used. In one of these, 3 differentially-connected overcurrent relays are operated in Y from the Δ-connected secondaries of 3 current transformers in the line side of the grounding transformers. This is equivalent to differential protection on an ordinary transformer at times when no load is being carried by the secondary, since in the grounding transformer the secondary Δ winding carries no external load; it provides protection against both turn-to-turn short-circuit and internal grounds occurring in the transformer or on the conductors between the transformer and the current transformers. The other method compares the zero phase-sequence currents on both sides of the grounding transformer by means of 3 line current transformers connected in parallel and balanced against a current transformer connected in the neutral. Since turn-to-turn faults do not result in zero phase-sequence currents this method does not protect against such faults but functions on faults to ground only. In applying these forms of protection it is important that the characteristics of the operating current transformers be checked up to maximum short-circuit values.

IMPRESSIONS

In looking over the preceding recommendations one cannot fail to be impressed by the prominent place still occupied by the simple overcurrent relay in the protection of a wide range of electrical apparatus. Even where it has been supplanted in the first line of defense by more highly selective devices, it still is relied upon as a safeguard of last resort. Nor is this surprising when it is remembered that in any analysis of the destructive effect of dielectric rupture, the major damage is brought about by the thermal or magnetic effects of *high currents.* This thought tends to strengthen the belief that the persistence of the overcurrent relay as an important protective agent is destined to extend well into the future.

Growing interconnections have brought increasing problems to the operating engineer, and his demand for the rapid isolation of faults has brought similar problems to the relay designer. In recent years the trend has been toward the attainment of greater operating speeds with increased selectivity. However, progress in fields other than that of the relay also is to be recorded: Current transformers offering uniform characteristics up to exceptionally high currents are now on the way, and circuit breakers capable of interrupting these currents in a brief period of time already have been developed.

No discussion on protective methods can be complete without some reference to the primary position of the insulation itself. That improvements have been effected in apparatus insulation during recent years cannot be questioned; but there are quite obvious economic factors limiting the extension of the insulation to a point of absolute dependability under any and all conditions. Direct lightning strokes still are to be feared and the dangers from them cannot be overcome economically by increased insulation. Beyond the point at which greater insulation becomes impracticable the relay always must find its place in the protective economy of the electrical system.

# Safe Harbor-Westport

## 230-Kv Transmission Line

**Designed according to the latest ideas concerning lightning protection, the Safe Harbor-Westport 230-kv line is said to be the most heavily insulated so far constructed. Ground wire protection has been applied according to the latest theory, and special effort has been made to reduce tower to ground resistances.**

By
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Pwr. Co., Baltimore, Md.

RELIABILITY of transmission has been a matter of foremost importance in the design and construction of the 230-kv line connecting the Safe Harbor hydroelectric plant with the Westport steam station in Baltimore. This has been so not only because a large portion of the ultimate capacity (510,000 hp) of the Safe Harbor plant will be available for Baltimore, but also because during certain periods Baltimore will be dependent primarily upon Safe Harbor power.

Selection of high operating voltage was made only after a thorough investigation of (1) the relative economics and reliability factors involved, (2) the possibility of future interconnections, and (3) system stability. Studies made jointly with engineers of the Consolidated Gas, Electric Light and Power Company covered a comparison of 2 230-kv circuits with 6 110-kv circuits. These studies included also investigation of such problems as terminal location, 2-point versus single-point supply, the use or omission

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Based upon "Safe Harbor-Westport 230-Kv Transmission Line" (No. 32M16) presented at the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., Oct. 10-13, 1932.

of high voltage buses, and amount of synchronous condenser capacity required. An a-c calculating board was employed to check the results obtained by analytical methods. The decision finally was made in favor of the higher voltage as offering lower cost, greater reliability, and greater possibilities for interconnection.

### ROUTING OF LINE

Voltage regulation on the network in Baltimore, and control of short-circuit currents made advisable the delivery of power to each side of the city. As shown in Fig. 2, the present line circles the city and enters from the south; the second line as projected will terminate to the east of the city near the site of a future steam station. Routes for the 2 lines diverge on leaving the Susquehanna River and are so widely separated that the possibility of a lightning storm affecting both circuits simultaneously is almost non-existent. At present, Westport is the center of distribution in Baltimore; therefore, the termination of the line at this point called for less additional investment in distribution facilities.

Most of the terrain traversed by the line is rather rugged, and about 23 of the 70 miles is wooded. As the country is thickly settled, wire and railroad crossings are frequent. These include 4 66-kv and 12 railroad crossings, all of which increased the cost of wire stringing. The right-of-way is 150 ft wide and consists of part easements and part fee simple.

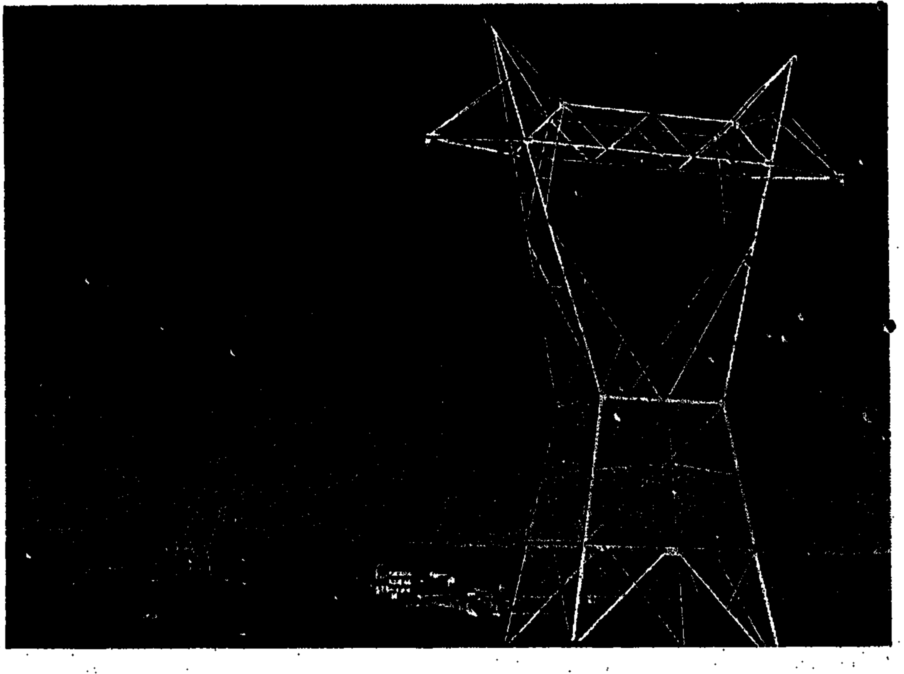

Fig. 1. A section of the line showing a type A tower in the foreground

Actual design and construction of the line were preceded of course by the usual preliminary surveys and detailed engineering studies. Lightning being considered the worst enemy of transmission lines in this part of the country, special design features were incorporated to minimize troubles from that source; these features include increased insulation, 20 10-in. suspension units with 5-in. spacing, and ground wires installed in accordance with the best design information available.

After the approximate location had been determined, and before the actual surveying of the property had begun, the route was photographed from the air, and the final route was laid out on a mosaic made to a scale of 1,000 ft per in. Later a profile was plotted from the United States Geological Survey map, from which the average span length and height of tower were determined. Final specifications were so drawn that the designers were not limited to any particular type of tower as designs submitted by manufacturers varied greatly in appearance and weight. A final selection was made from the various designs after a comparison on the basis of towers erected in the field. Details of some of the more interesting features of the line are given in the paragraphs that follow.

### TOWERS

Originally 3 types of towers were used as a basis for design: type A for straight line and angles up to 3°; type B for angles from 3° to 15°; and type C for angles over 15° and for dead ends. Type A was modified to meet railroad specifications, the modified form being designated as type E. Later a transposition tower was brought out as type D.

As shown in Figs. 1 and 3, the towers are of the waist line type. (See "Load Test Check Tower Designs," by R. W. Wilbraham, *Electrical World*, Nov. 12, 1927.) This design gives the lowest footing reactions and by the use of body extensions permits variations in the length of leg with a minimum number of pieces. Sags and cable tensions were computed on the basis of N.E.L.A. heavy loading. In determining tower loadings one broken conductor

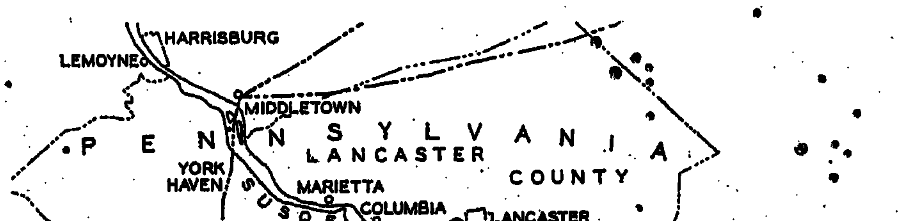
HARRISBURG
LEMOYNE
MIDDLETOWN
PENNSYLVANIA
LANCASTER COUNTY
YORK HAVEN
MARIETTA
COLUMBIA
SUSQUEHANNA RIVER
SAFE HARBOR
LANCASTER
YORK COUNTY
YORK
PENNA WATER & POWER CO.
COATESVILLE
HOLTWOOD
HANOVER
P.W.&P. CO.
PENNSYLVANIA
MARYLAND
CONOWINGO
PARKTON
WESTMINSTER
MARYLAND
FINKSBURG
HAVRE DE GRACE
BELAIR
PERRYVILLE
CONS. GAS ELEC. LIGHT & POWER CO. OF BALTO.
BALTIMORE
PRATT ST.
WESTPORT
GOULD ST.
ELLICOTT CITY
ELKRIDGE
CHESAPEAKE BAY
WASHINGTON
ANNAPOLIS
LEGEND
220,000 V. LINES OF P.W. & P. CO. (BUILT)
70,000 V. LINES OF P.W. & P. CO. (BUILT)
220,000 V. LINES OF P.W. & P. CO. (PROPOSED)
130,000 V. SINGLE-PHASE LINES OF P.W. & P. CO. (PROPOSED)
70,000 V. LINES OF C.G.E.L. & P. CO. (BUILT)
HIGH-VOLTAGE LINES AND INTERCONNECTIONS WITH OTHER COMPANIES
HYDRO-ELECTRIC PLANTS
STEAM PLANTS
Ⓦ POWRR IS SOLD TO C.G.E.L. & P. CO.
Ⓧ POWER IS SOLD TO CHESTER VALLEY ELEC. CO.
Ⓨ POWER IS SOLD TO EDISON LIGHT & POWER CO. (INSULL SYSTEM) AND INTERCHANGED WITH ASSOC. GAS & ELECTRIC SYSTEM
Ⓩ POWER IS SOLD TO PENNA. POWER & LIGHT SYSTEM

Fig. 2. Map showing routing of the Safe Harbor-Westport 230-kv line

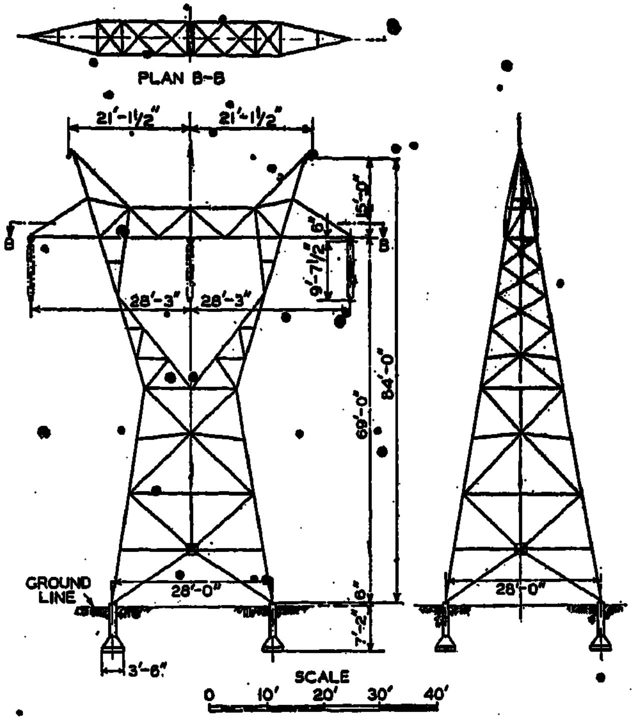

Fig. 3. Details of type A suspension tower

**Table I—Allowable Stresses for Tower Design Loadings**

| Limiting Values of Slenderness Ratio | |
|---|---|
| Main members | 150 |
| Other compression members | 200 |
| Redundant members | 250 |
| **Allowable Unit Stresses (lb per sq in.)** | |
| Tension on net section | 25,000 |
| Compression (gross section) | $25{,}000 - 90\frac{L}{R}$ |
| Shear on bolts | 20,000 |
| Bearing | 40,000 |

**Table II—Tower Weights in Pounds**

| | Type A | Type B | Type C |
|---|---|---|---|
| Tower | 10,724 | 12,725 | 23,202 |
| 15-ft extension | 2,941 | 3,275 | 5,761 |
| 30-ft extension | | | 11,792 |
| 60-ft extension | | | 33,320 |
| Std. leg | 189 | 326 | 568 |
| −5-ft leg | 142 | | |
| −2.5-ft leg | 177 | 275 | 478 |
| +2.5-ft leg | 343 | 507 | |
| +5-ft leg | 393 | 569 | 920 |
| +10-ft leg | 678 | 944 | |
| Anchor material | 386 | 654 | 2,018 |

at a tension of 10,000 lb was assumed for "A" towers; dead end towers were assumed to have 3 broken conductors and 2 broken ground wires stressed to the elastic limit. All fittings are designed for a vertical load corresponding to one inch of ice on the conductors. Table I gives allowable stresses for design loadings. For test purposes all design loads were increased 25 per cent. Weights of the towers are shown in Table II.

Phase separation and length of crossarm were determined from the clearance diagram shown in Fig. 4. The ground wires were located so as to give maximum protection against a direct lightning stroke. Originally only 2 transpositions were contemplated. A third, however, was added at the request of another utility company. The original transpositions are somewhat unusual in that only 2 conductors are transposed at each point. This is sufficient to balance the conductors against each other but does not balance them against outside exposures; the transposition requested by the other utility was for this latter purpose and had to be complete. It was made by placing 2 transposition towers consecutively in the line.

For all but dead-end towers concrete foundations of the inverted mushroom type are used; these are designed for 100 per cent overload. This type of foundation can be built as cheaply as the grillage type; also it makes possible much closer alinement, resulting in a considerable saving in cost of erecting towers. Foundations for dead-end towers consist of angle iron stubs carried down to the bottom of the excavation and set in concrete. The average amount of concrete required for line towers is 4 cu yd; for dead-end towers 25 cu yd.

## Conductors and Ground Wires

Before the final selection was made several types and makes of conductors were investigated, and their effects on spacing and height of towers studied. After comparing the various designs, a 795,000-cir mil A.C.S.R. (aluminum cable steel reinforced) conductor was chosen. The most advantageous combination of other metals considered would have required towers 5 ft higher than those designed for use with the conductor selected, would have been considerably higher in cost, and did not offer sufficient advantage to offset this difference in cost. Physical characteristics of conductors and ground wires are shown in Table III.

Conductor and ground wire tensions were held low (see Table III) in order to guard against vibration troubles. In addition, armor rods were provided at all suspension clamps. Sags and tensions were calculated from actual stress-strain curves as determined on tested samples 50 ft in length. During normal conditions, the sag of the ground wire is 5 ft less than that of the conductor. When loaded with $^1/_2$-in. of ice, these wires will parallel the unloaded conductors. Sags were adjusted without prestretching and are somewhat less now than they will be after being subjected to an ice load.

No effort was made to secure any special slip features in the suspension clamps as the J-bolts automatically limit the pressure on the conductor. Armor rods are secured by ovoid clamps which do not present any points or sharp edges to start corona streamers. Compression type clamps are used for all dead-ends and splices, the steel and aluminum being held separately. Dead-end towers are bridged by underslung bolted jumpers.

## Insulators

Insulators at all suspension points are standard 10-in. suspension disks with 5-in. spacing. Suspension strings consist of 20 units and are doubled at all points where the load exceeds 4,500 lb. Clearances are provided for grading rings but none is used at the present time. On all dead-end towers double strings consisting of 20 10-in. 25,000-lb strength insulators with 5$^3/_4$-in. spacing are used.

## GROUNDING

Ground wire protection is based upon a tower footing resistance of 50 ohms or less. A field check, however, showed that footing resistances varied from 1 ohm to 400 ohms with an average of 79 ohms; only 6 of the 351 towers had footing resistances below the 50-ohm limit.

Several different methods for reducing the ground resistance were investigated and some of them tested in the field. The method finally adopted as being most effective employs a 50-ft wire extending out radially from each corner of the tower, and buried about 20 in. below the surface of the ground. Each of these wires terminates in a salt treated grounding rod. The average resistance to ground of 4 wires and rods is 34 ohms. In a few cases the addition of these wires was insufficient to reduce the combined resistance to 50 ohms. Adding more wires in such cases proved rather disappointing, however, as the additional reduction amounted to only 10 or 15 per cent.

In order to determine the comparative effectiveness of a longitudinal counterpoise, about 4$^1/_2$ miles of $^3/_8$-in. copperweld wire was buried along a section of line. As far as low frequency resistance is concerned, this proved less effective than 4 radial wires, and is more costly.

## SPECIAL FEATURES

Both the present and the proposed 220-kv lines to Baltimore are brought out from the upstream face of the power house, across the forebay to a hill on the east shore of the river. This hill will be the site of a future high-voltage switching station. On top of the hill the lines swing around to a river crossing on the downstream side of the power house. The distance across the river at this point is 5,725 ft. An island situated in mid-stream is used as a tower site and the crossing made in 2 spans of 2,880 and 2,845 ft, respectively. The hills on either side of the river are at el 500 and 450, while bed rock on the island is found at el 170.

High water in the river will reach el 190; hence any tower placed on the island must be set above this elevation to protect it against water and ice. Accordingly, the tower piers have been made heavy enough to withstand the maximum load expected from ice and water. To avoid building 2 sets of such piers, it was decided to place both circuits on one tower; this tower is 183 ft high, and has a spread at the base of 75 ft and a crossarm 146 ft long. The steel structure is carried down to bed rock where it is anchored with 24 2-in. bolts sunk 9 ft in the rock. The lower 25 ft of the tower legs are encased in concrete. The total weight of the tower is 180,000 lb.

Conductors in the crossing are 803,000 cir mils A.C.S.R. strung to a tension of 7,500 lb, and the ground wires 286,000 cir mils A.C.S.R. strung to a tension of 5,650 lb. Maximum tensions are 17,565 and 13,380 lb, respectively.

The problem of stringing this crossing presented some difficulties. The island was too narrow for a "reel set up" and therefore the cables had to be pulled from the shore to the island. Motive power was furnished by an electric power winch. The river bed at this point is full of submerged rocks so that the cables had to be kept above the water surface to guard them against injuries. The tension required to keep the cable from sagging down into the water however made it extremely difficult to pull the cable out. The problem was solved by stringing a $^5/_8$-in. steel messenger cable and trolleying the conductors over on the messenger.

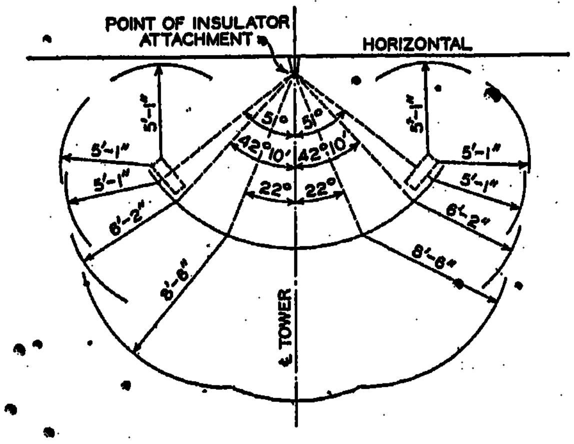

Fig. 4. Clearance diagram for type A tower

**Table III—Characteristics of Conductors and Ground Wires**

| | Conductor | Ground Wires |
|---|---|---|
| Size A.C.S.R. | 795,000 cir mils | 203,200 cir mils |
| Per cent steel | 39.5 | 71.9 |
| Stranding | 30x0.1628-in. al.<br>19x0.0977-in. steel | 16x0.1127-in. al.<br>19x0.0977-in. steel |
| Diameter | 1.140 in. | 0.714 in. |
| Weight per foot | 1.234 lb | 0.6785 lb |
| Ultimate strength | 37,770 lb | 26,600 lb |
| Elastic limit | 27,250 lb | 18,620 lb |
| Tension at assumed maximum load (1/2-in. ice, 8-lb wind, 0° F) | 12,000 lb | 9,060 lb |
| Tension at 60° F | 6,175 lb | 4,180 lb |

The line was built during a period of low material

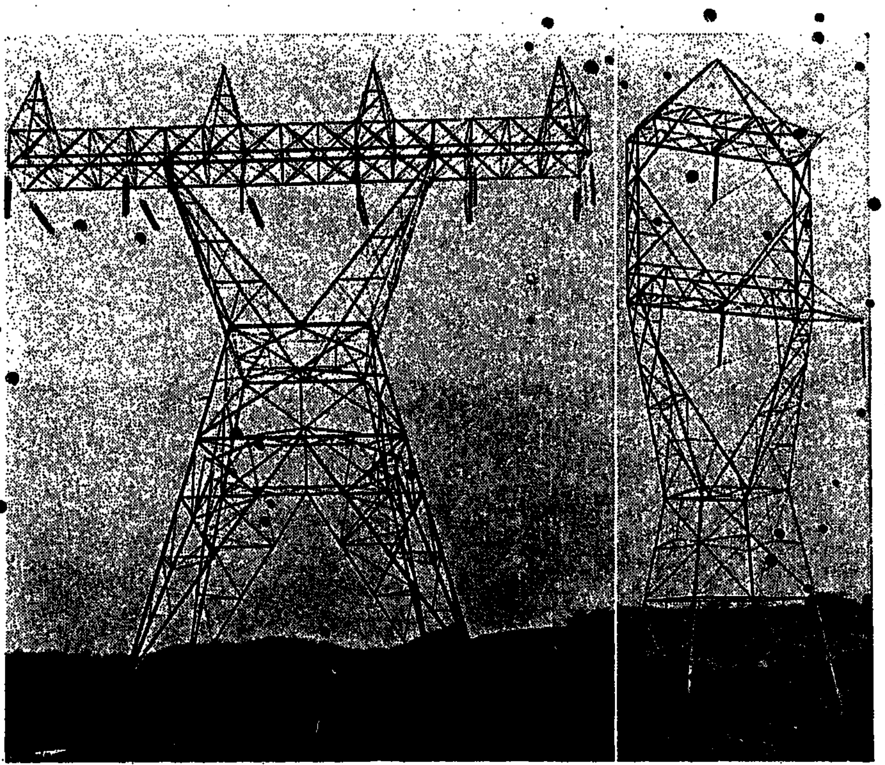

Fig. 5. (Right) Type D transposition tower

Fig. 6. (Left) Double circuit river crossing tower on island just below the Safe Harbor plant prices and plentiful supply of labor. The right-of-way department kept well ahead of construction so that work, when once started, proceeded without delay. Actual field work began March 1, 1931, and the line was turned over to the operating department December 4, 1931, 9 months and 4 days after the work was initiated. Mechanical equipment kept the organization small (150 men maximum) and helped to speed up the work.

Much has been said about the frailty of A.C.S.R. and about the precautions needed to protect it against damage. The Safe Harbor-Westport line was strung without any special safeguards, yet it stands completed with only 3 repair sleeves, 2 of which could have been left off. In addition to these, about 150 ft of cable had to be cut out because of damage when a conductor jammed in a roller block which had not been closed properly.

# Pulp Insulation for Telephone Cables

After some 40 years of service spirally wrapped paper insulation is rapidly being displaced for interoffice and subscriber loop cables, by a pulp insulation applied directly to the conductor by a process which brings the paper mill into the cable plant and combines the paper making and insulating operations into one process with the elimination of a number of costly intermediate steps. In addition, this process makes possible the use of a less expensive material as an insulating medium.

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INSULATED wire of a type considerably cheaper than paper ribbon insulation has been developed. The insulation is formed from paper pulp directly on the conductor by a special type of paper-making equipment. This equipment is not critical to the kind of pulp used but for the purposes of durability, strength, and economy a Kraft wood pulp has been used in telephone cables. The process has progressed through the development stage and is now in continuous operation in the commercial production of all the principal exchange area cables of 24 and 26 A.W.G. conductors used in the Bell system. (Fig. 2.) Thousands of miles of lead-encased pulp insulated cables, ranging in size from the smallest consisting of 11 pairs to the largest consisting of 1,818 pairs, are now giving satisfactory service and because of the substantial economies which the construction promises for the finer wire cables, attention is being directed toward its possible application to larger gage cable conductors and to its use as an insulating medium for other electrical circuits.

For many years conductors for lead-sheathed telephone cables were insulated by helically wound strips of paper made from a stock composed of all old rope, or old rope and a small admixture of cotton. In an effort to find a suitable less expensive fiber, however, a formula composed of about 40 per cent chemical wood pulp and the remainder rope stock was adopted in 1920 for the larger sizes of paper only. This wood fiber is of the spruce or other coniferous tree species prepared by the sulfate or Kraft process. Extensive tests have demonstrated that it compares favorably in stability and permanence with the well-established manila fiber. In the case of the newly developed pulp insulated cable, the raw material used is 100 per cent Kraft wood fiber.

Work was initiated in 1921 to determine the possibilities of producing a continuous homogeneous paper covering directly on the wire. Preliminary tests were sufficiently interesting to warrant proceeding further with the project. A 10-wire machine was started up in 1924, with very indifferent success, but succeeding developments in technique and improvements in equipment resulted in a product so satisfactory that the machine was expanded to a 50-wire capacity and put in operation early in 1928. In 1931, 10 more wires were added. The product was cabled into 26 and 24 A.W.G. cables on standard cabling equipment with no major difficulties, and installed in commercial telephone plant by

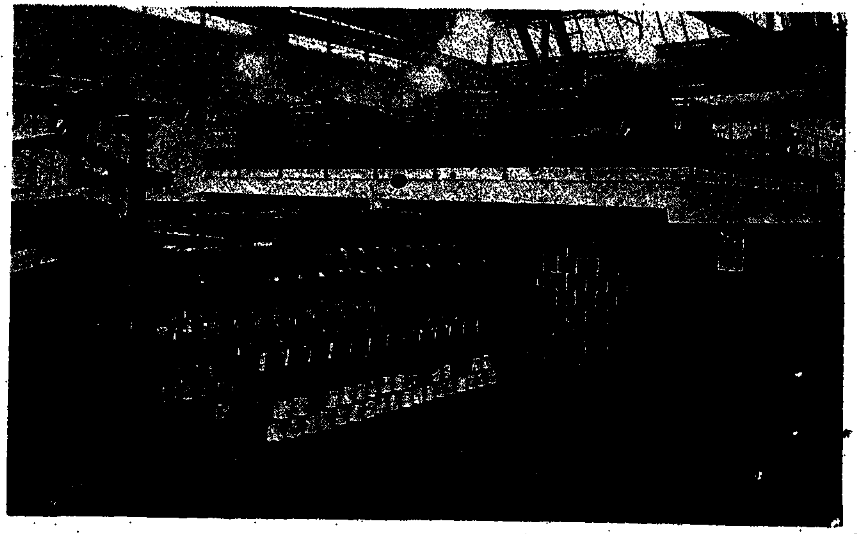
Fig. 1. Wire supply and pulp preparation equipment

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Based upon "Pulp Insulation for Telephone Cables" (No. 32-122) presented at the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., October 10–13, 1932.

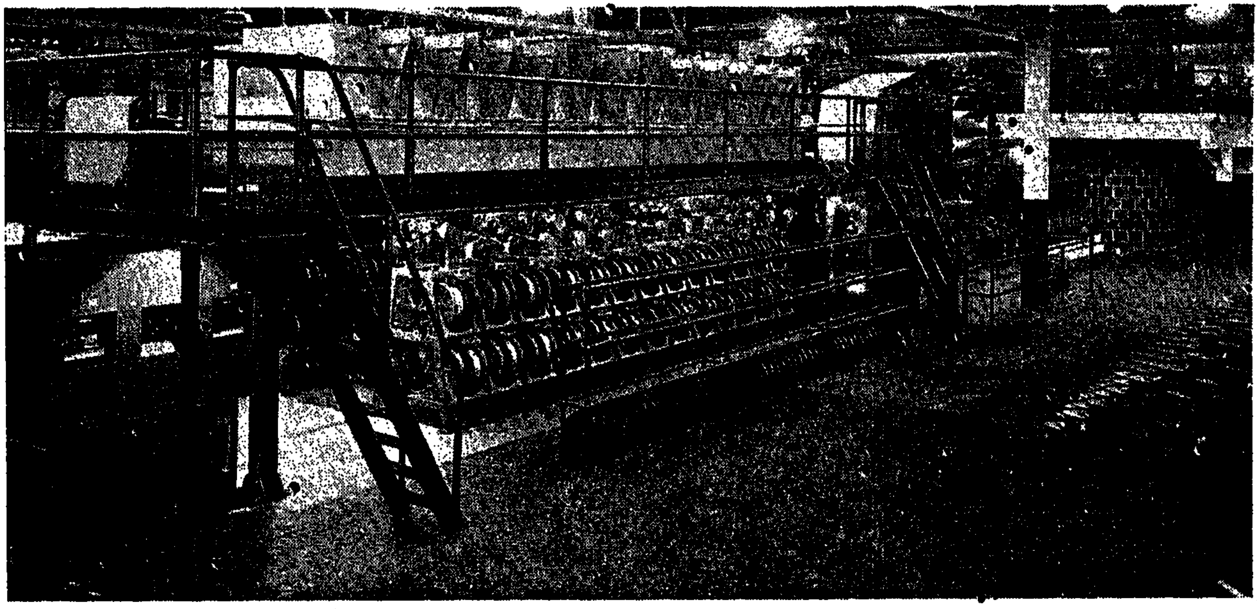

Fig. 2. General view of pulp insulating equipment. The take-up and dryer are shown in the left foreground; the polishers and wet machine in the right center; and the wire supply and pulp preparation equipment in the right background

the operating companies. No serious operating trouble has developed in any of this cable.

The pulp insulated wire capacity now at the Hawthorne and Kearny plants is approximately 225,000,000 conductor feet per week and all 24 and 26 A.W.G. exchange area cables are being manufactured from pulp insulated wire.

## PROCESS OF MANUFACTURE

The insulating material which is to be placed on the wire is given practically the same treatment in a beater as it would receive in paper making, but without the addition of sizing or loading. The beaten pulp is stored in a large tank from which it is pumped to a mix box for dilution with water before passing to the screen where coarse particles and lumps are removed. (Fig. 1.)

For the next operation a modified paper machine of the cylinder type is used. The mixture of pulp and water is fed into the cylinder vat by gravity from the screen. The cylinder mold itself is divided into 60 narrow uniform sections by dams or deckles on the surface of the wire cloth covering. The bare conductors coming to the machine are guided so that one conductor passes around the mold in each of the sections. As the mold is rotated in the water suspension of pulp in the vat, a narrow continuous sheet of paper with a conductor embedded in it is formed in each section by the simple paper making process of straining the fibers from the suspension as the water flows through the fine wire cloth covering the mold, under the slight head maintained outside the mold. These sheets are transferred from the mold to a woolen felt by the pressure of a couch roll and carried by it through 2 presses which take out a considerable part of the water and leave the material in shape to be turned down to the final form. This is done by passing the conductors embedded in the narrow sheets through individual polishers which turn the wet sheet down into a uniform covering of a size determined to a large extent by the amount of pulp deposited in the sheet. These polishers are simply rapidly rotating heads carrying 3 specially shaped blades so arranged that 1 blade deflects the traveling wire and sheet from a straight line against the other 2, with a pressure controlled by the tension on the wire.

Table I—Approximate Fiber Concentrations

| Step in Manufacture | Per Cent | Step in Manufacture | Per Cent |
|---|---|---|---|
| Beater | 3.5-4 | Cylinder vat | 0.05 |
| Storage | 1.3 | Polishers | 28 |
| Screen | 0.07 | Completed insulation | 91 |
| | | Finished cable | 100 |

The wet cylindrical insulation is then dried to about a 9 per cent moisture content by a single passage through a horizontal electric furnace 26 ft long, the wet end of which is maintained at a temperature of about 1,500 deg F and the dry or tempering end at something under 800 deg F. The wires are carried through the drier by a rotary pulling mechanism designed to minimize the crushing or flattening of the dried insulation. This device delivers the finished product to the take-ups for spooling. The machine is operated at about 130 ft per min.

Considerable amounts of water are used in the process, for in this, as in all paper making processes, water acts not only as a carrier for the fibers, but it forms some sort of a loose chemical or mechanical combination with them in the beater and is one of the principal factors in determining the final characteristics of the material. The approximate fiber concentrations at the various steps of manufacture are given in Table I.

In theory the whole process is remarkably simple, but from the practical standpoint many intricate problems had to be solved before satisfactory operation was possible. Means, for example, had to be worked out for shifting from an empty spool of wire to a full one without shutdown or break in conductor or insulation. Also methods of restringing broken wires with the machine in operation had to be developed. Continuous 6-day week operation now is possible without shutdowns except for the mid-week clean-up. The satisfactory working out of many other details also was necessary to secure the present smoothness of operation.

## PHYSICAL CHARACTERISTICS

The physical characteristics of pulp insulation, some of which are shown in Table II, may be modified somewhat by choice of materials and methods of manufacture, but they cannot be controlled entirely. The comments which follow cover only the sizes which have been run almost exclusively to date, namely 24 and 26 A.W.G. wire, but it should be noted that wires ranging in size from 19 to 28 A.W.G. have been covered successfully.

The physical characteristics shown in Table II are controlled by the beating of the pulp, the amount of pulp fed to the machine, the dryness of the sheet in the polishers, and the speed of drying. The tensile strength and flexibility of the insulation can be varied through wide limits by different treatments during manufacture. The elongation is quite comparable to that of ordinary paper and is not susceptible of much variation. The insulation is made sufficiently strong and flexible to withstand the various operations incident to cable fabrication and subsequent handling yet not so tough that it cannot be readily removed from the wire at the point of splicing.

**Table II—Some Physical Characteristics of Pulp Insulation**

| Characteristic | Range of Values Obtainable |
|---|---|
| Diameter of insulated wire—inches | 0.030 to 0.050 for 24 A.W.G.<br>0.026 to 0.040 for 26 A.W.G. |
| Weight of dry pulp—grams per foot. | 0.045 to 0.12 for 24 A.W.G.<br>0.040 to 0.095 for 26 A.W.G. |
| Density—ratio of fiber to total volume | 35% to 55%—independent of gage |

The surface of the insulation has a rather rough blotting paper appearance, though some variation is possible by changes in the beating. The cross-section is circular with the conductor in the center in the ideal case, but because of limitations imposed by practical operating considerations there is a tendency toward some eccentricity and flattening of the insulation.

## DESIGN OF PULP INSULATED CABLES

Telephone cable circuits are normally subjected to only a low dielectric stress; this permits their being placed in close proximity to one another. Thus the primary requirement of the insulation is that it be distributed in a thin layer of uniform application, with the wire well centered so that each conductor when packed into a cable is completely insulated from its neighbors throughout its length. The mean radial thickness of the pulp insulation for the 26 A.W.G. wire is less than 0.01 in., and for 24 A.W.G. wire is about 0.011 in. The pulp is prepared and applied to the conductor in such a manner that the fibers pack together to form a cover with sufficient strength and elasticity to withstand the handling the insulated wire must receive and yet be as light as possible in weight per unit volume in order to obtain the best electrical characteristics.

Pulp insulated wire is structurally more like textile insulated wire than air spaced paper ribbon insulated wire. The insulation is firm with no appreciable air gap between it and the wire, and bundles of wires nestle together differently when grouped into a given space. Furthermore, it was found that when pairs of conductors were stranded together in the usual manner of concentric layers each reversed in direction, the unit thus formed was considerably less flexible than the standard construction. This is apparently caused by the greater frictional resistance between layers, thus causing sharp kinks for even moderate bends. While this feature is less pronounced for small cables, it is, of course, objectionable and an improvement in the handling qualities is effected by stranding several layers in the same direction rather than employing the single reverse layer construction.

For the large size cable, a design whereby the pairs are first grouped into units of 51 or 101, all the pairs in these units being stranded in the same direction and the units then stranded together into a cable, gives a construction which seems to offer the most satisfactory arrangement. Thus, for example, a 1,212-pair cable is made up of 12 units of 101 pairs each, arranged with 4 units in the center and 8 in a surrounding layer, and an 1,818-pair cable is laid up with 2 units in the center surrounded by 6 units in the first layer and 10 units in the second layer. A short section of 1,818-pair 26 A.W.G. cable with the units separated is shown in Fig. 3. One might expect these rather large units would not group themselves together into a circular shape without poor utilization of the space they occupy but it has been found that by properly constructing the individual units and by suitable arrangement of the cable layup, a cross-section is obtained with the groups keystoning together nicely and presenting no noticeable voids.

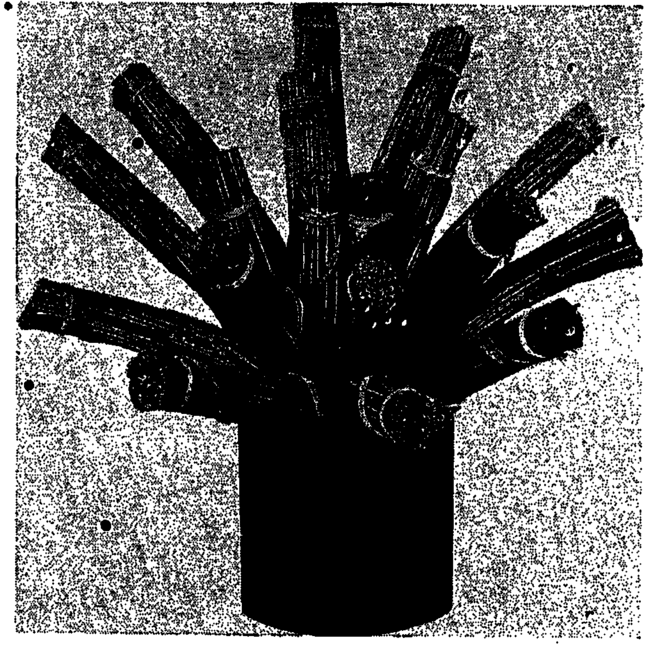

**Fig. 3. Section of 1,818-pair 26 A.W.G. cable showing units separated**

The cable core must also have a certain firmness or density to give the best support to the sheath and insure satisfactory handling as the cables are being installed. With ribbon paper insulation the ratio of the amount of insulation to the non-copper space in a cable was found to be a fairly good criterion of the firmness required. With the fundamentally different physical characteristics of the pulp insulated wire this relationship was altered and experimental trials were therefore necessary to determine the approximate size of pulp insulated wire most suitable for the space it was to occupy in cable form. There is some latitude here in the distribution of a given amount of fiber but taking into account both the mechanical and electrical requirements, the diameter for the insulated conductor finally selected as the most satisfactory for the series of standard cables of 24 A.W.G. was 0.041 in. and for 26 A.W.G., 0.033 in.; and the aim in manufacture is to produce an insulation as uniformly close to these dimensions as possible. These diameters are measured by a volume displacement method. Short samples, as representative as possible of the wire under consideration, are inserted for a given distance into a small bore tube of mercury and the displacement noted. The gage is calibrated so that mean diameters are read directly on the scale.

The above specific sizes of pulp insulated conductors apply only to cables designed for a particular set of characteristics. As in the case of ribbon paper cables, the amount of insulation for a given gage of conductor may be varied within reasonable limits, so as to produce cables of other characteristics.

## ELECTRICAL CHARACTERISTICS

It was reasoned that pulp insulated cables would probably be inherently higher in mutual capacitance than similar sizes of paper ribbon cables because, considering the insulated wire itself, in the case of helically applied strip insulation the volume of air beneath the paper is about equal to the volume of the paper itself, while for pulp insulation there is very little air space between the insulation and the wire. This fundamental difference could be somewhat compensated for, however, by the introduction of more air into the spaces between the fibers of the pulp insulating medium than is found in the paper ribbon itself, but it was not expected that it would entirely neutralize the effect of lack of air space next to the wire. It was appreciated, however, that the aim should be to get as low density insulation as possible still consistent with obtaining a continuous, flexible, and strong covering on the wire and emphasis was placed on this phase from the start of the development. In Fig. 4 is shown graphically the progress that has been made in reducing the mutual capacitance of 24 A.W.G. cable since early in 1928. Although a substantial improvement has been made in lowering the mutual capacitance to within less than 4 per cent of the corresponding ribbon paper cable, a further reduction would have considerable value, warranting more effort in that direction. For 26 A.W.G. cable the excess in capacitance is even less than for 24 A.W.G., and furthermore, it is not so objectionable from a transmission standpoint as in the case of the larger gage.

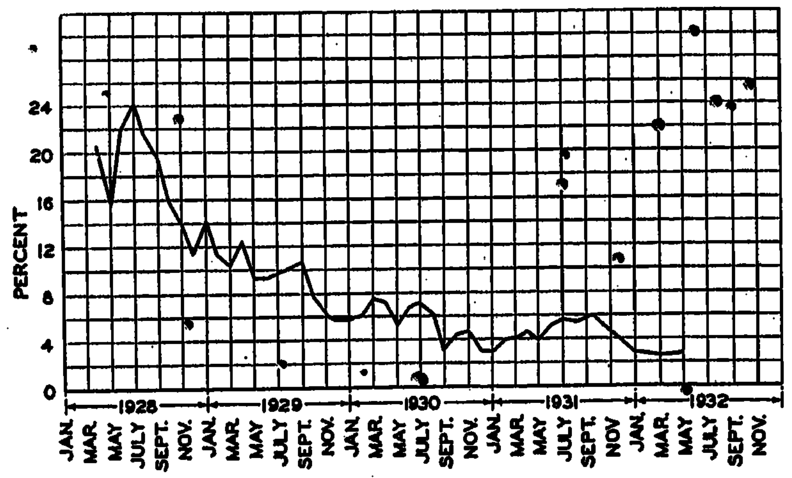

**Fig. 4. Curve showing improvement in mutual capacitance since early 1928**

The percentage is that by which the capacitance of 24 A.W.G. pulp insulated cables exceeds that of ribbon insulated cable

The principal factors which have brought about this reduction in capacitance are improvements in the treatment of the pulp itself, refinements in machinery operation to permit the use of a lower density covering on the wire, the more rapid drying out of the moisture from the pulp resulting in less shrinkage of the insulation on the conductors, and the producing of more nearly round and better centered insulation. Of these factors perhaps the one having the greatest effect on lowering the mutual capacitance was that of improving the out-of-roundness of the insulated conductors. In studying this phase of the problem, advantage was taken of the effect of flatness of the insulation on the component parts which make up the mutual capacitance. The mutual capacitance of a pair of wires is composed of the direct capacitance between the 2 wires augmented by a series arrangement of 2 other direct capacitances, one from each of the 2 wires to the grounded group consisting of all other wires and sheath. As 2 wires with oval shape insulation are twisted, there is a decided tendency for 2 flat sides to stay together resulting in the average separation of wire and mate being less than where circular sections are involved. To determine accurately the degree of out-of-roundness representing the average condition throughout a length of cable by mechanical means is next to impossible, whereas the direct capacitance between wire and mate automatically integrates this condition. Measurements therefore are made of the component direct capacitances and their ratio used as a sensitive indicator of the effect of flatness of the insulation on the mutual capacitance. By using the ratio of capacitances the cable length error is eliminated and accurate determination can readily be made on short lengths of cable. In Fig. 5 and Table III are given data which were obtained on 4 short lengths of pulp insulated

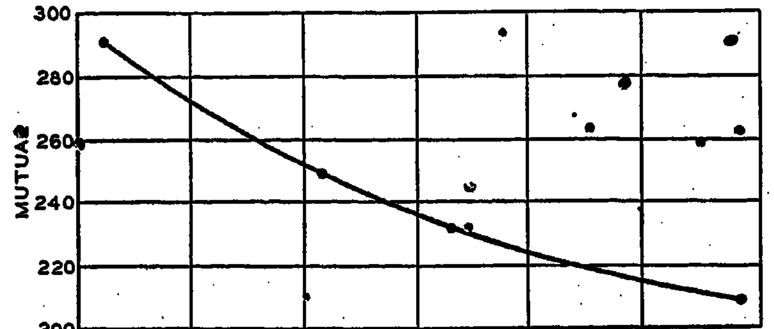

**Fig. 5. Curve showing mutual capacitance versus direct capacitance to ground divided by direct capacitance to mate**

cables which so far as was known differed only as regards the lack of symmetry of the insulation.

The a-c mutual conductance follows the trend of the capacitance, resulting in the ratio of conductance to capacitance at a frequency of 900 cycles per sec being somewhat higher than the standard ribbon paper cable, but not of a magnitude such as to introduce any serious transmission loss for these fine gage circuits. The d-c insulation resistance is of the same order as that of strip paper cables.

The dielectric strength of the insulation is ample, being somewhat higher on the average than that of similar strip paper cables. A rather extensive series of mechanical tests comparing pulp and ribbon types of insulated cable under controlled conditions simulating those met with in actual installation, showed that the pulp insulated cables remained superior to the ribbon cables as regards dielectric strength but that under extreme loads they would not withstand quite as much stretch as the ribbon insulated cable without mechanical damage to the insulation.

## Installation Features

No new features are involved in installing pulp insulated cable except in the splicing of the conductors after the lengths as supplied from the factory have been placed in position in the plant. This operation, however, is a considerable factor in the total time of the installation procedure because in a not unusual run of a mile of an 1,818-pair cable, there may be as many as 40,000 joints to be made involving the stripping of twice that number of ends of insulated wire preparatory to joining the copper conductors.

Immediately upon removing the lead sheath from the ends of the cables thus exposing the dry insulation to the atmosphere, absorption of moisture rapidly takes place. It is customary therefore to boil out the ends of cable with paraffin wax before starting the splicing operation. With strip insulation this wax also aids in preventing the insulation from unfurling. It was found that even the most flexible pulp insulation so far produced, when impregnated with unmodified paraffin, would not withstand satisfactorily the handling incident to splicing at low temperatures. A softer and more lubricating type of compound is required and a suitable combination has been found by adding paraffin oil to the paraffin wax. Different proportions of oil and wax are used depending upon the temperature at the time of installation, and the compounding is done at the point of splicing. At an atmospheric temperature of about 75 deg F no oil is required and below 10 deg F about half oil and half wax makes a suitable compound with proportionate amounts of oil for intermediate temperatures. In Fig. 6 is shown the stripping characteristics of typical pulp insulation on a few inches of 24 A.W.G. conductor impregnated with compounds of different proportions of paraffin wax and oil.

Table III—Capacity Measurements Indicating Symmetry

Mutual Capacitance vs. $\frac{\text{Direct Capacitance to Ground}}{\text{Direct Capacitance to Mate}}$

Average Value in $\mu\mu f$.

| Sample | Mutual | $D_M$ | $D_G$ | $D_G/D_M$ |
|---|---|---|---|---|
| 1 | 292 | 187 | 201 | 1.07 |
| 2 | 250 | 144 | 207 | 1.42 |
| 3 | 233 | 126 | 209 | 1.66 |
| 4 | 206 | 101 | 221 | 2.19 |

In starting to make a splice, the insulated conductors are brought together in proper position, given a sharp crossover, the wires cut off so as to give several inches of free end, the insulation broken at the crossover, and then stripped off the ends. Thus the ideal insulation is one which when waxed can readily be parted at the crossover and when broken will slip freely along the wire, yet will withstand considerable bending and folding at other places in the splice without breaking. Pulp insulation tends to cling to the conductor somewhat more than a paper tube of strip insulation and although there is considerable variation in this characteristic in the product as now manufactured, it is sufficiently under control so that with a small amount of experience a splicer applying his usual technique is able to handle even 26 A.W.G. wire with little breaking of the conductors. There is, of course, with pulp no raveling of the insulation and the cotton sleeves which are used to insulate the joint, slip over the ends of the wires rather more readily than for the spirally applied paper. Thus the over-all time required for joining a given number of pairs is practically the same for the 2 types of insulation.

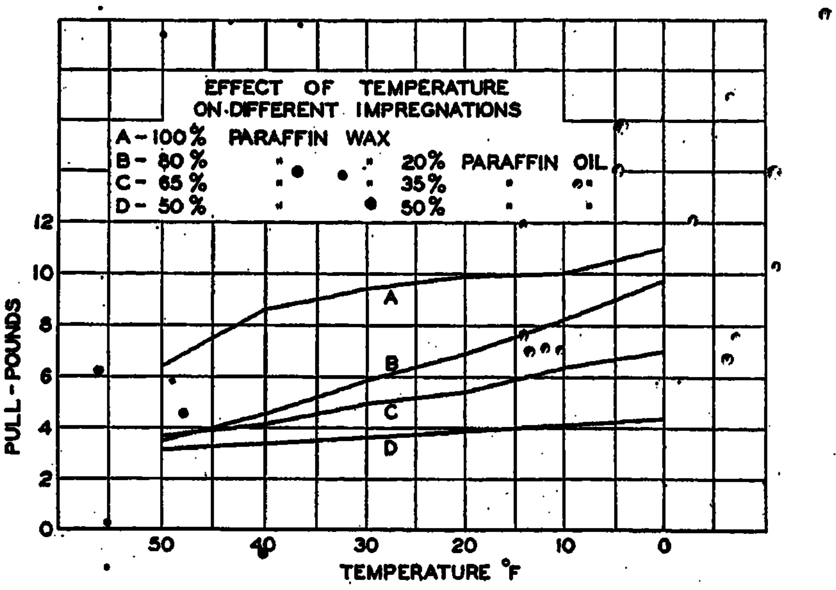

Fig. 6. Curve showing effect of atmospheric temperature on pull required to strip insulation impregnated with various wax and oil mixtures

An unbleached pulp is used and the natural brownish color of the Kraft stock results in less sharp color distinction for the different groupings of pairs than where ribbon insulation is used. However, by simplifying the color code so as to require only red, blue, and green, besides the natural color, sufficient contrast in the shades is obtained so that there is no difficulty in distinguishing colors in the splicing operation.

Preliminary cost figures indicated that this process offered the possibility of a considerable saving over the ribbon process. These predictions have been verified by actual machine operation extending over a period of more than 3 years. The savings are made possible by the low cost of Kraft pulp as compared with manila paper and by the elimination of the intermediate paper making, paper slitting, and handling operations.

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# Dynamic Braking of Synchronous Machines

**Accurate and practical formulas for determining the number of revolutions and time required to stop a synchronous machine by dynamic braking are presented in this article, thus enabling the prediction of dynamic braking performance comparable with that of other machine characteristics. The method is new to the extent that it treats variable speed short circuits.**

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ROTATION of synchronous machines frequently must be stopped as quickly as possible. The electrical methods of accomplishing this are plugging and dynamic braking. Plugging consists of reversing the phase rotation of the voltage applied to the armature winding. Dynamic braking consists of short-circuiting the armature through an external resistor and maintaining field excitation. Following a comparison of these 2 methods, the results of an analytical treatment of dynamic braking are given.

Independent of the type of braking used, the stored energy in the rotating system must be converted into some other form, usually heat. Analyses of a number of particular applications of synchronous motors to steel and rubber mills, where quick stops are necessary, have shown that practically all of the stored energy in such systems is in the motor rotor. The normal means of dissipation of this energy are the windage, friction, copper and core losses of the motor, and the friction of the rolls. Generally, unless the rolls are loaded, the amount of energy dissipated in them is negligible, being of the same order of magnitude as their stored kinetic energy. The neglect of both these factors is therefore a compensating error. The other means of energy dissipation are functions of the method used.

In plugging, the phase rotation of the supply voltage is reversed, the performance then being similar to that during starting except that the motor slip varies from two to one instead of from one to zero. At the time the speed becomes zero, the power must be removed to prevent a reversal of rotation. This method of phase reversal is subject to several outstanding objections, the most prominent of which are:

1. Unless the power supply is large, the system disturbance resulting from the switching operations may be very undesirable.
2. The torque developed for a usual motor is small, thus limiting the rate at which the system can be stopped unless a specially designed amortisseur winding is used. This special design of amortisseur winding, beneficial to stopping, frequently is detrimental to other machine characteristics.
3. If reversal is to be prevented, the power supply must be controlled accurately so that it may be removed at the instant the motor reaches zero speed. This introduces complications in the control circuits which can be avoided by other stopping methods.

In dynamic braking the armature is short-circuited through an external resistor and field excitation is maintained. The operation is that of a generator short-circuited through an external resistor. The theory of such operation from the standpoint of constant speed has been treated thoroughly in previous publications. The dynamic braking cycle differs from these treatments in that as the rotational energy of the system is dissipated, the speed of the machine decreases. The rate of this dissipation depends greatly upon the resistance used, as will be shown.

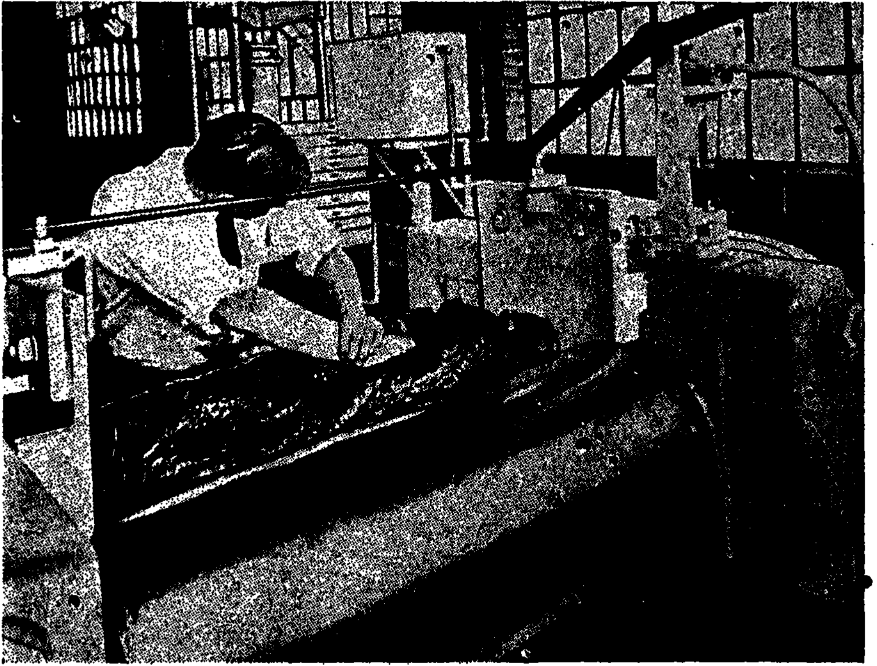

**Fig. 1. A typical application where rapid braking is necessary**

In order to present a comparison of the 2 methods, Table I has been prepared showing the number of revolutions made before stopping and the time in

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Full text of "Dynamic Braking of Synchronous Machines" (No. 32-67) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932.

seconds required for each of the 2 methods. The figures are based on an average 1,000-hp unity-power-factor, mill-type motor. They represent calculated results based on the theory which follows.

ANALYTICAL RELATIONS

To determine the relations during the braking cycle an expression for the instantaneous armature current is obtained from the vector diagram of a suddenly short-circuited generator with known speed decrease. The instantaneous torque in synchronous kilowatts is obtained from the armature current and effective circuit resistance. This is equated to the rate of change of kinetic energy due to speed reduction. There results a differential equation which when solved gives the speed-time curve in terms of the machine constants. Experience has shown that there are 2 satisfactory methods of solving this equation. The first, based upon the assumption of constant effective excitation, gives an equation for the speed-time curve as follows:

$$t = \frac{2H}{e_d'^2 r}\left\{\frac{x_d'^2}{2}(1 - n^2) - r^2 \log n + \frac{r^2}{2}\left(\frac{x_d'}{x_q} - 1\right)^2 \log \frac{n^2 x_q^2 + r^2}{x_q^2 + r^2}\right\} \quad (1)$$

where

$t$ = time in seconds
$H$ = stored kinetic energy in kw-sec per unit normal kva
$e_d'$ = excitation behind transient reactance at the instant of applying the short circuit
$r$ = total internal and external armature resistance
$x_d'$ = direct axis transient reactance
$n$ = per unit speed
$x_q$ = quadrature axis synchronous reactance.

The number of revolutions made by the machine upon reaching a given speed is then obtained by changing the variable in the speed-time equation and integrating. This is:

$$R = \frac{N_0 H}{30 e_d'^2 r}\left\{r^2(1 - n) + \frac{x_d'^2}{3}(1 - n^3) - r^2\left(\frac{x_d'}{x_q} - 1\right)^2\left[(1 - n) - \frac{r}{x_q}\left(\tan^{-1}\frac{x_q}{r} - \tan^{-1}\frac{n x_q}{r}\right)\right]\right\} \quad (2)$$

where

$R$ = total revolutions up to any time
$N_0$ = revolutions per minute at synchronous speed.

The total revolutions made to stop are found by placing correct boundary conditions in the above equation, and solving. The result is:

$$R_s = \frac{N_0 H}{30 e_d'^2 r}\left\{r^2 + \frac{x_d'^2}{3} - r^2\left(\frac{x_d'}{x_q} - 1\right)^2 \times \left(1 - \frac{r}{x_q}\tan^{-1}\frac{x_q}{r}\right)\right\} \quad (3)$$

where

$R_s$ = total revolutions to stop.

The optimum value of resistance to be used in order that the revolutions to stop are a minimum, considering all of the machine quantities to remain constant, is obtained by differentiating $R_s$ with respect to $r$ and neglecting the less significant terms. This value is:

$$r_0 = \frac{x_d'}{\sqrt{3}}$$

The second method of solution is based upon variable excitation with an assumption regarding the manner of variation. Analysis of a number of oscillograms taken during the dynamic braking cycle has shown that the field current can be represented very closely by a single exponential form, the time constant however being shorter than that of the field under short-circuited armature conditions.

Table I—Revolutions and Time to Stop

| Motor Speed r.p.m. | Plugging |  | Dynamic braking |  |
|---|---|---|---|---|
|  | Rev. | Time (Sec) | Rev. | Time (Sec) |
| 1,200 | 15.60 | 1.72 | 9.00 | 0.98 |
| 600 | 5.50 | 1.21 | 4.32 | 0.95 |
| 300 | 2.90 | 1.28 | 2.40 | 1.05 |
| 150 | 1.65 | 1.45 | 1.41 | 1.24 |
| 72 | 1.02 | 1.87 | 0.85 | 1.56 |

Using this assumption there results a relation between the machine quantities, speed and time, as follows:

$$\frac{E_f^2}{r_f^2}t - \frac{2E_f\left(I_B - \frac{E_f}{r_f}\right)}{r_f\,\alpha}(\epsilon^{-\alpha t} - 1) - \frac{\left(I_B - \frac{E_f}{r_f}\right)^2}{2\alpha}(\epsilon^{-2\alpha t} - 1) = \frac{2HI_{af}^2}{r}\left\{\frac{x_d^2}{2}(1 - n)^2 - r^2 \log n + \frac{r^2}{2}\left(\frac{x_d}{x_q} - 1\right)^2 \log\frac{n^2 x_q^2 + r^2}{x_q^2 + r^2}\right\} \quad (4)$$

where

$E_f$ = volts, field
$r$ = field ohmic resistance

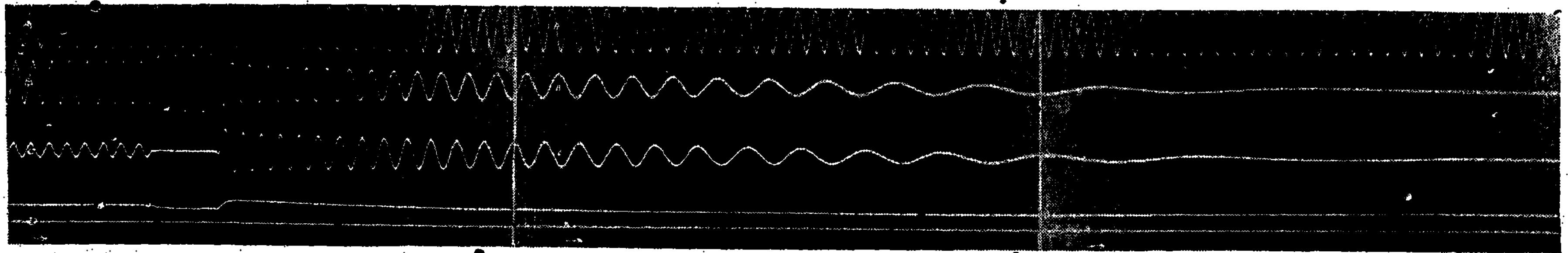

Fig. 2. Dynamic braking cycle of a synchronous motor

Curve $A$—60-cycle timing wave Curve $B$—terminal voltage Curve $C$—armature current Curve $D$—field current

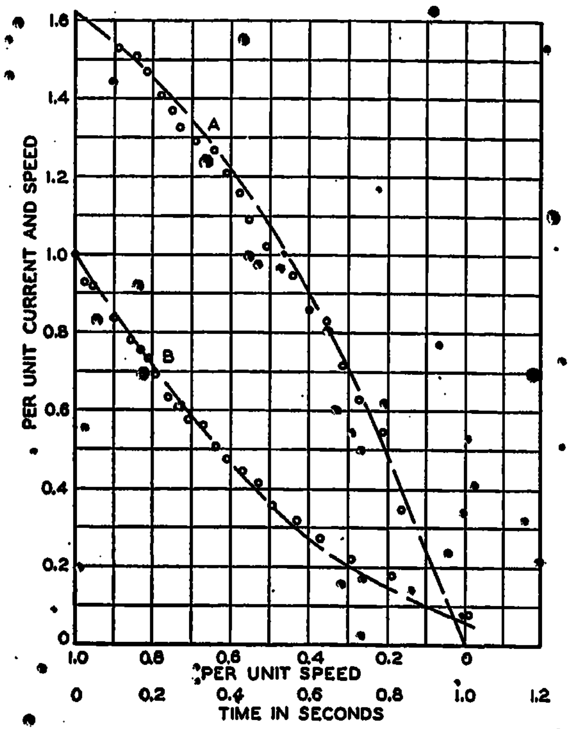

**Fig. 3. (Left) Current and speed characteristics during the braking cycle shown in Fig. 2**

Curve *A*—per-unit current vs. per-unit speed

$$i_n = e_d' \left\{ \frac{x_q^2 + \left(\frac{r}{n}\right)^2}{\left(\frac{r}{n}\right)^2 + x_d' x_q} \right\}^{1/2}$$

where $i_n$ is per-unit armature current at per-unit speed

Curve *B*—per-unit speed vs. time. (See eq. 1)

Test points indicated by small circles

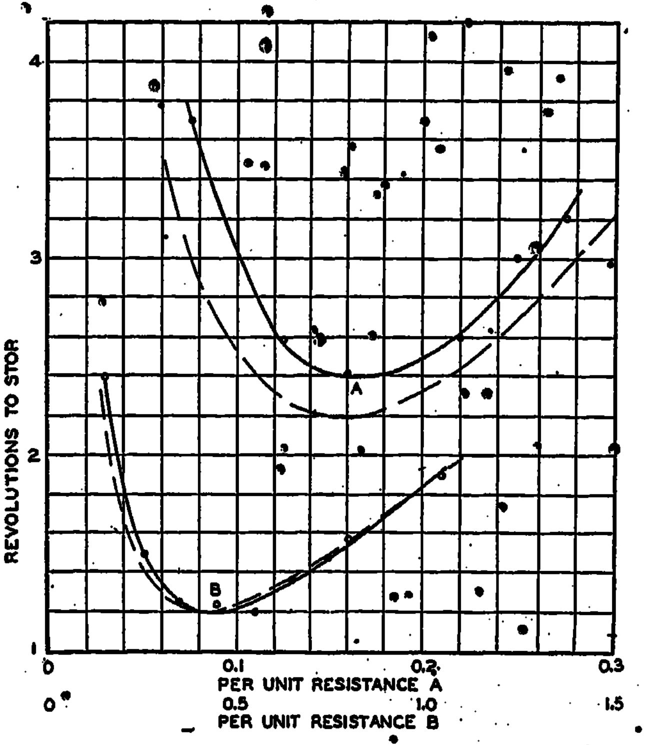

**Fig. 4. (Right) Effect of external resistance on stopping revolutions**

Curves *A*—600-hp, 12-pole, 600-rpm, 0.8-power factor motor

Curves *B*—500-hp, 40-pole, 180-rpm, 0.8-power factor motor

Test curves in full lines

Calculated curves in broken lines. (See eq 3)

$I_B$ = field amperes after disconnecting from line
$\alpha$ = apparent decrement factor of field decay
$I_{fo}$ = amperes field to produce normal open circuit terminal voltage on air-gap line
$x_d$ = direct axis synchronous reactance.

The left hand side of the equation has only time functions, and the right hand side has only speed functions. Being of transcendental character, no explicit solution is available, but the desired result may be obtained by plotting the 2 sides of the equation and finding the time and corresponding speed for which they are equal.

## Discussion of Results

The theoretical results are based on the premise that saturation may be neglected, but their application to a practical machine must include saturation effects in the determination of the initial conditions and in the determination of the instantaneous excitation. This is evident, because regardless of the initial terminal voltage applied, and the initial field current, there is some point during the speed decrease at which normal flux is reached. As the machine passes this point, saturation plays an increasingly greater part in the effective excitation. Since this excitation enters the determination of the stopping revolutions as the square, its accurate calculation is imperative. Satisfactory results would not be possible in many practical applications if saturation were omitted.

The assumption of constant effective excitation will embrace a large majority of applications, in fact will be sufficiently accurate for most calculations.

In the case of a braking cycle being initiated with the machine under load, it is interesting to note that the revolutions to stop, due to the rate of electrical energy dissipation will usually be greater than would occur under initial no-load conditions. The presence of the shaft load, if it continues, will of course aid in the stopping and bring the machine to rest sooner than the no-load condition in spite of the fact that the rate of electrical energy dissipation is less.

The effect of corrective power factor is to increase the effective excitation and consequently improve the stopping cycle. If, however, the power factor necessitates a larger diameter machine than could otherwise be used, the increased mechanical energy storage may more than offset the gain obtained from a greater rate of dissipation. The proper proportioning of a particular machine depends upon these 2 factors, and to obtain good results a careful balance must be found.

## Comparison Between Test and Calculated Results

In Fig. 2 is shown an oscillogram of the relations during the dynamic braking of a 500-hp, 40-pole, 180-rpm, 0.8-power factor synchronous motor whose constants are:

$x_d$ = 1.45 $x_q$ = 1.02 $x_d'$ = 0.65 $e_d'$ = 1.34 $N_0$ = 180
$H$ = stored energy per kva = 0.493 second
$r$ = total per-unit armature resistance = 0.53

In Fig. 3 is shown a comparison between test and calculated current-speed and speed-time curves from the oscillogram of Fig. 2. The agreement between the curves is quite satisfactory. Fig. 4 shows test and calculated revolutions to stop vs. per-unit armature resistance on 2 synchronous motors, one of which is the one given previously and the other is a 600-hp, 12-pole, 600-rpm, 0.8-power factor machine whose constants are:

$x_d$ = 0.89 $x_q$ = 0.52 $x_d'$ = 0.22 $e_d'$ = 1.27
$H$ = 0.762 $N_0$ = 600

The general shapes of the test and calculated curves are similar although there is a fairly constant difference between the curves on the 12-pole motor.

Of particular interest is the fact that the agreement between test and calculated values at the optimum resistance is quite good. This is true of the revolutions to stop as well as the current-speed and speed-time curves. As the resistance is increased or decreased with respect to the optimum the agreement is less satisfactory. The minimum revolutions as determined by the equation for $r_o$ are 2.45 for the 12-pole motor and 1.22 for the 40-pole motor. The test curves give, respectively, 2.42 and 1.20.

# Economic Aspects of Water Power

Among developments of the past decade that have enhanced the usefulness of hydroelectric power are the present large size of electric utility systems, the peaked nature of their loads, advances in long distance power transmission, and various improvements in the design and construction of hydroelectric plants. In this article the value of water power is analyzed in terms of the 2 main components of the cost of steam power—capacity and energy.

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DURING THE PAST DECADE, water power in all those regions of the North American Continent where it is employed in conjunction with thermal sources of power has undergone a gradual but pronounced change in its economic relationship to steam power. Two main components make up the economic value of water power—capacity and energy. The capacity value of hydroelectric plants, that is the cost of procuring equivalent capacity service by other sources of power, so far has not been affected measurably by advances in the art of constructing thermal plants; but the energy value or the cost of producing energy by other means has been reduced greatly in recent years.

This downward trend in energy value may be traced chiefly to 2 causes: improvements in thermal economy and the declining price of fuel; and in a minor way only to miscellaneous causes such as reduction in maintenance cost and operating labor due to improvements in design, and concentration of large capacity in comparatively few units. There is some well warranted expectation that the future trend of average fuel prices will be decidedly upward, but probably not sufficient to overbalance materially the effect of further improvements in thermal economy that may be realized in the future.

Since the total energy output for a given water power site is limited by natural conditions of discharge and head, the gain in energy output due to various refinements in the efficiency of energy conversion is necessarily only of minor importance. It is evident, therefore, that the most fruitful field of endeavor for enhancing the economic value of water power will lie in the direction of (1) reducing the investment cost per kilowatt to a point where the carrying charges will compare favorably with equivalent cost of steam power; and (2) increasing the total amount of economically installed capacity beyond the formerly accepted limits and coordinating the operation of the combined sources so that such additional economic hydroelectric capacity can be utilized to render firm peak service to the power supply system of which it is a part.

The purpose of this article is to review briefly the parallel developments in the economics of water power in respect to these 2 main components, energy and capacity, and to give an outline of future possibilities for enhancing the economic value of water power.

## Factors Controlling Choice of Hydro or Steam

Few electric systems in this country are supplied wholly by hydroelectric generation, chiefly because it has been economically advisable and often necessary to provide, by means of steam plants located near load centers, reserve generating capacity for use during periods of low water flow. There is no generally accepted ratio of hydroelectric to steam capacity for best economic results; the optimum proportion for any system is determined by the relative investment cost, fuel costs of steam energy, and characteristics of system load and water supply.

Fundamentally, the benefit derived from the 2 sources of supply comes from combining the low operating energy cost of water power with the low unit investment cost of steam; while the total investment to carry the system peak may be larger in a combined system than with steam alone, the excess investment is more than compensated by the

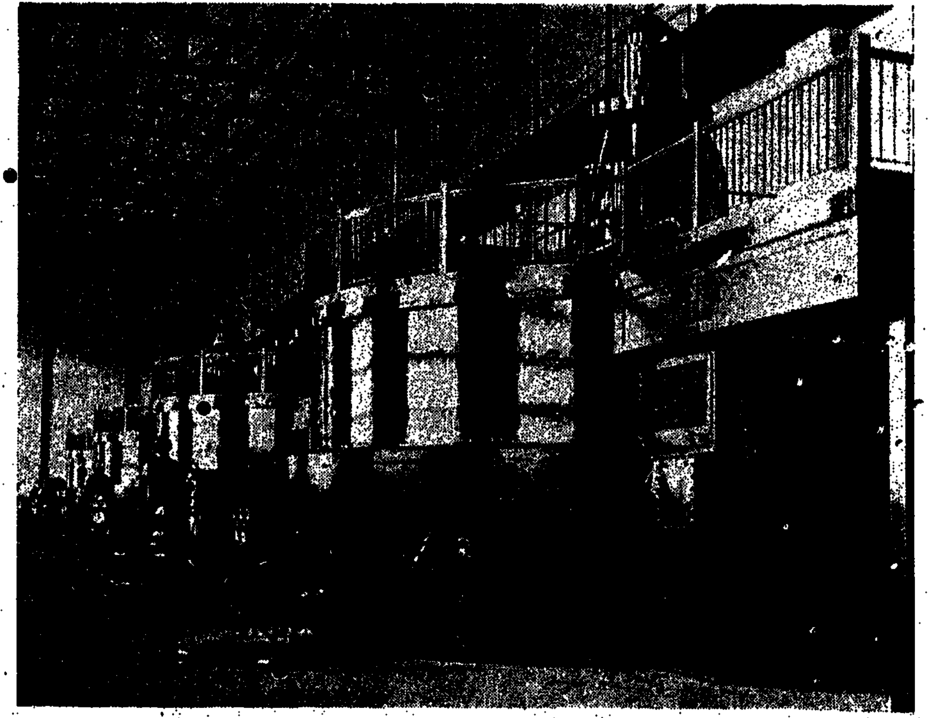

**Fig. 1. Generator room of the Safe Harbor hydroelectric plant on the Susquehanna River, a large low-head run-of-river pondage plant**

Each of the 36,000-kva generators is driven by an automatically adjustable blade Kaplan turbine

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Full text of the first part of a paper "Economic Aspects of Water Power" (No. 32-128) presented at the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., Oct. 10–13, 1932.

low cost of energy derived from water power. The 2 sources of power should be regarded as supplementing rather than competing with each other. Quick-starting characteristics of hydroelectric units, namely, the ability to start them from standstill and synchronize them with the load in a small fraction of the time required for steam units, provides a high degree of standby readiness for emergencies. Hydroelectric units, especially of the low head type having short water passages, are well adapted to maintain system frequency. Water storage can be drawn upon to relieve the steam plants of the task of ironing out discrepancies in the forecasting of system load demands, to save banking extra boilers and generation by less efficient units, and to facilitate the advance scheduling of equipment for generation as well as for withdrawal from service for inspection and maintenance. Hydroelectric generators also are adapted to no-load operation as synchronous condensers for voltage regulation or power factor correction without consuming much energy or requiring elaborate precautions against overheating or rubbing as in steam units.

## FIRM HYDROELECTRIC CAPACITY

The best method of operating a combined water power and steam system is generally to schedule the hydroelectric plants for maximum efficiency in periods of deficient water, and for maximum energy output in periods of plentiful water. Operation is simplified where water storage is available during low flow periods, hydroelectric capacity then can be held ready for instant use in case of emergency at associated steam plants. Water power always supplies a belt on the system load curve according to water availability such that the largest possible hydroelectric capacity is utilized; associated steam plants thus are operated at improved load factors in periods of deficient water.

That portion of the hydroelectric capacity which under certain assumed conditions (generally coincidence of highest system load demands with minimum flow) controlling the capacity investment for the system as a whole, will render the same capacity service in the upper portion of the system load curve that an alternative steam plant might perform, is called *firm hydroelectric capacity*. With large storage and favorable load conditions, the firm capacity of the first hydroelectric plant connected to a load system may be many times the minimum 24-hr power available. However, the minimum flow energy for a second hydroelectric plant feeding into the same load system will yield a relatively smaller firm capacity than the energy from the first plant, that is, the increment gain in firm hydroelectric capacity per unit of hydroelectric energy will decrease with an increase in the total amount of hydroelectric energy available.

## RECENT DEVELOPMENTS FAVORING WATER POWER

Certain factors of increasing advantage to hydroelectric development have made possible, and hold promise for still greater usefulness of, numerous hydroelectric projects that would not have been considered economically feasible during preceding years, notwithstanding the higher unit value of energy in those years. Among these factors is the present large size of electric utility systems in consequence of natural growth as well as of the interconnection of contiguous load areas. Almost without exception, new large scale hydroelectric developments are made by electric systems that supply either metropolitan load centers or a group of systems covering a regional territory.

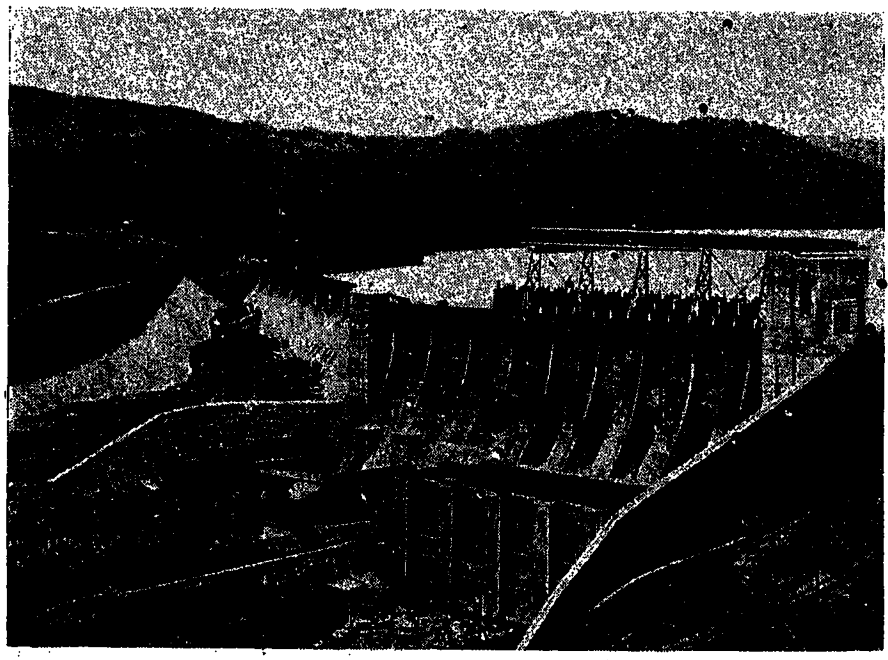

Fig. 2. Fifteen Mile Falls plant on the Connecticut River, a typical low-head storage plant

Shape of the peak of electric system loads is favorable for utilizing a large installed capacity in hydroelectric plant under minimum water conditions, which allows a large capacity value to be allotted to water power. Especially in the region along the Atlantic seaboard the sharp peaks of the various metropolitan load centers, although seasonal and of short duration, may occur simultaneously at the same hour and on the same day. This lack of assured diversity in load demand of interconnected systems, while unfavorable from the point of view of over-all power cost, gives storage-equipped hydroelectric plants an opportunity to utilize a greater portion of their installed capacities for firm peak service on the combined system.

Another feature of large utility system loads has been the annual increase in peak, which has been of such an amount that within a comparatively short time the entire capacity of new hydroelectric developments has become usable on the peak. At the same time the minimum system load is sufficient to absorb a large hydroelectric output when water is plentiful in run-of-river plants. Plants that can be developed beyond the continuous flow capacity at a low incremental cost can produce a great deal of low cost secondary energy.

Advances in the art of power transmission have made it possible to transmit large capacities over long distances at reasonable cost, with good voltage regulation and with low energy losses. In some instances step-up switching stations at the hydroelectric plants and step-down terminal stations of transmission lines can be developed advantageously as integral parts of interconnection projects; thus large power systems that formerly functioned as separate units are tied together into a regional power system extending over a large area. In this manner a dual function is performed by the transmission and tie-in investment, especially on systems where 230 kv has been adopted as the standard transmission voltage. The high degree of service reliability of all types of equipment at this voltage has encouraged designing engineers to simplify their system layouts and to rely more on higher mechanical and electrical factors of safety in equipment than on a multiplicity of lines and reserve apparatus; this has a tendency to reduce investment cost or increase the service value of hydroelectric projects. Most recent operating experience with high voltage transmission lines embodying some advanced features of design, has been so satisfactory, that lightning proof operation of transmission lines is within the range of possibility at a not too distant future.

At the hydroelectric plant proper, several factors have contributed toward lowering the investment cost, aside from the lower price levels of structures and machinery. With construction plants laid out for low handling cost and rapid progress, and with careful engineering work applied to temporary structures, flood control, etc., the period of construction has been shortened; substantial amounts thereby are saved that formerly were expended on interest and other carrying charges during construction. Economies in the cost of financing are made possible by the sponsoring or underwriting of major enterprises through existing large utility systems, and few projects are undertaken now for which the market has not been secured in advance at least to the extent necessary to insure the interest on bonded indebtedness with a sizable margin of earnings.

It is possible now to get more capacity out of a given structural space, not only because of the increased size of units, but also because of the higher specific speed of turbine runners and improved design of water passages. Higher speed and improved design of machinery have lowered the cost of main turbine and generator equipment. Auxiliary apparatus has been simplified and its cost decreased. No appreciable improvement in best efficiency of runners has been recorded during the past decade, at the beginning of which peak efficiencies in excess of 90 per cent already had been reached; however, with the advent of the adjustable blade Kaplan turbine high efficiency can be secured in low head plants over a much wider range of loading, and the over-all efficiency of energy conversion for the plant as a whole can be raised noticeably over that of earlier installations. Testing of models no longer is confined to runners and draft tubes, to observations of efficiency and output, and to studies of the cavitation problem; but extends to every phase of the project from headwater down to the lower end of the tailrace channel. As a result of model tests, more economic designs of spillways, pier and apron sections, flood gates, etc., have been developed. Effective steps have been taken at the newer plants to guard against service interference by trash and ice.

## PUMPED STORAGE PLANTS

Pumped storage plants involving specially constructed high or low level storage reservoirs do not play so important a part in the power supply scheme of large systems in the United States as they do in Europe. Several such projects are under discussion, but only one major installation, a plant built in 1928 on the Rocky River, a small tributary of the Housatonic River in New England, is actually in service. The plant pumps from the Housatonic River to a reservoir of 68,000 cfs-days usable capacity on the Rocky River. The average yearly runoff of the Rocky River is 17,000 cfs-days.

While pumping is done mainly by off-peak steam power, the Rocky River plant provides in addition seasonal storage service to other plants located below on the Housatonic River. Installation of the 24,000-kw generating unit in the Rocky River plant and the pumped storage reservoir actually added 40,000 kw of yearly firm capacity to the electric system served by the plant. The efficiency of direct recovery by the Rocky River plant alone is approximately 60 per cent, but on account of the lower plants the over-all conversion economy derived from all plants is raised to nearly 80 per cent.

## DUAL USE CAPACITY INSTALLATIONS

This novel type of development is related functionally to pumped storage plants, being based upon the principle of converting low cost off-peak energy into high value peak capacity and energy. It employs the same unit as a turbine-generator and a motor-pump set, without, however, requiring a specially constructed high or low level storage reservoir, conduits or hydraulic control equipment. It is especially adapted to those plants where the increment cost of generating and transmitting capacity is lower than that of equivalent steam capacity and where a substantial overlapping of heads can be arranged readily. Runoff characteristics should be such that, depending on the efficiency of the conversion cycle, the duration of the low flow stage, during which conversion of off-peak energy into peak energy takes place, is not too great compared with the duration of the excess flow period, during which the dual use equipment produces energy for the system. These conditions are somewhat interrelated: In some instances a large saving in investment cost may more than compensate for the extra cost of energy in conversion losses during low flow exceeding the gain in output during high flow, notwithstanding the fact that on such a project the low flow days may outnumber greatly the high flow days.

Operating the generator in reverse direction as a motor offers no serious difficulties. However, the design of different types of turbines and hydraulic structures for dual use at synchronous speed and the possibilities of variable speed electrical and hydraulic equipment have yet been developed not to such a degree that this simplified regenerative cycle can be adapted readily to those water power projects where natural conditions of the power site are favorable.

A great deal has been published in the technical literature, especially in Europe, on the principles and applications of pumped storage predicated in each instance on the employment of 2 separate hydraulic motors, one for generation and the other for pumping, and in nearly all cases also on the use of a specially constructed high or low level reservoir. Employing a single hydraulic motor for dual use omitting specially constructed reservoirs introduce substantial economies in capital investment, but involve a sacrifice in conversion efficiency.

Perhaps in the search for optimum efficiency, we are inclined at times to throw aside as unworthy of further study, the suggestion that a process admittedly inferior from a point of view of efficiency may yet be superior from the point of view of over-all economy. The simplified method of hydroelectric regeneration has not been treated so far in the technical literature. As a proper evaluation of the possibilities of this process is of some importance on account of its effect on the economics of future hydroelectric developments, the principles underlying this method as well as some empirical results from laboratory and field tests will be described in greater detail in a later article including an analysis of those factors that will limit its field of application.

## ANALYSIS OF HYDROELECTRIC POWER COSTS

Cost of hydroelectric power may be regarded as consisting of 4 main components, namely:

1. Base cost of the development, which is more or less independent of the amount of installed generating capacity.
2. Cost of generating capacity, including low voltage switching equipment.
3. Transmission investment, including step-up transformers and other high voltage equipment at the power house.
4. Tie-in investment, such as step-down transformer and switching stations, underground cables, and other special equipment necessary for delivering hydroelectric power to a distribution system or to a high voltage network.

Until quite recently it had been customary to group the first two components into the single item—cost of power plant. This practise usually was adequate for the purpose when investigating the economics of existing plants. However, segregation into the 2 components, base cost and increment cost, is almost indispensable during the preliminary or project stage of a new development in order to determine the most economic size of the initial and ultimate installation and the part that it should play in the power supply scheme of a territory. The fact that such a differentiation exists, that the 2 components can be segregated readily and that their relative magnitudes as well as their values per unit capacity furnish a yardstick for comparing one project with another, is one of the characteristic economic features of hydroelectric plants as distinguished from steam plants; in the latter the first component, base cost, ceases to be an important factor after more than one generating unit is installed.

Cost of dam, property, flowage rights, construction equipment and temporary structures, relocation of bridges, highways, railroads, general site improvements, a certain minimum of tailrace excavation, auxiliary station equipment, all of which to some extent are independent of the amount of capacity installed, constitute the base cost. For many reasons this cost for almost identical hydraulic conditions of head, average discharge, and length of backwater, may show variations of several hundred per cent.

The second component comprises the cost of generating equipment, hydraulic as well as electrical, power house substructure and superstructure, low voltage switching and auxiliary equipment, intakes, control equipment, increment tailrace excavation, and related equipment. It sometimes is called the

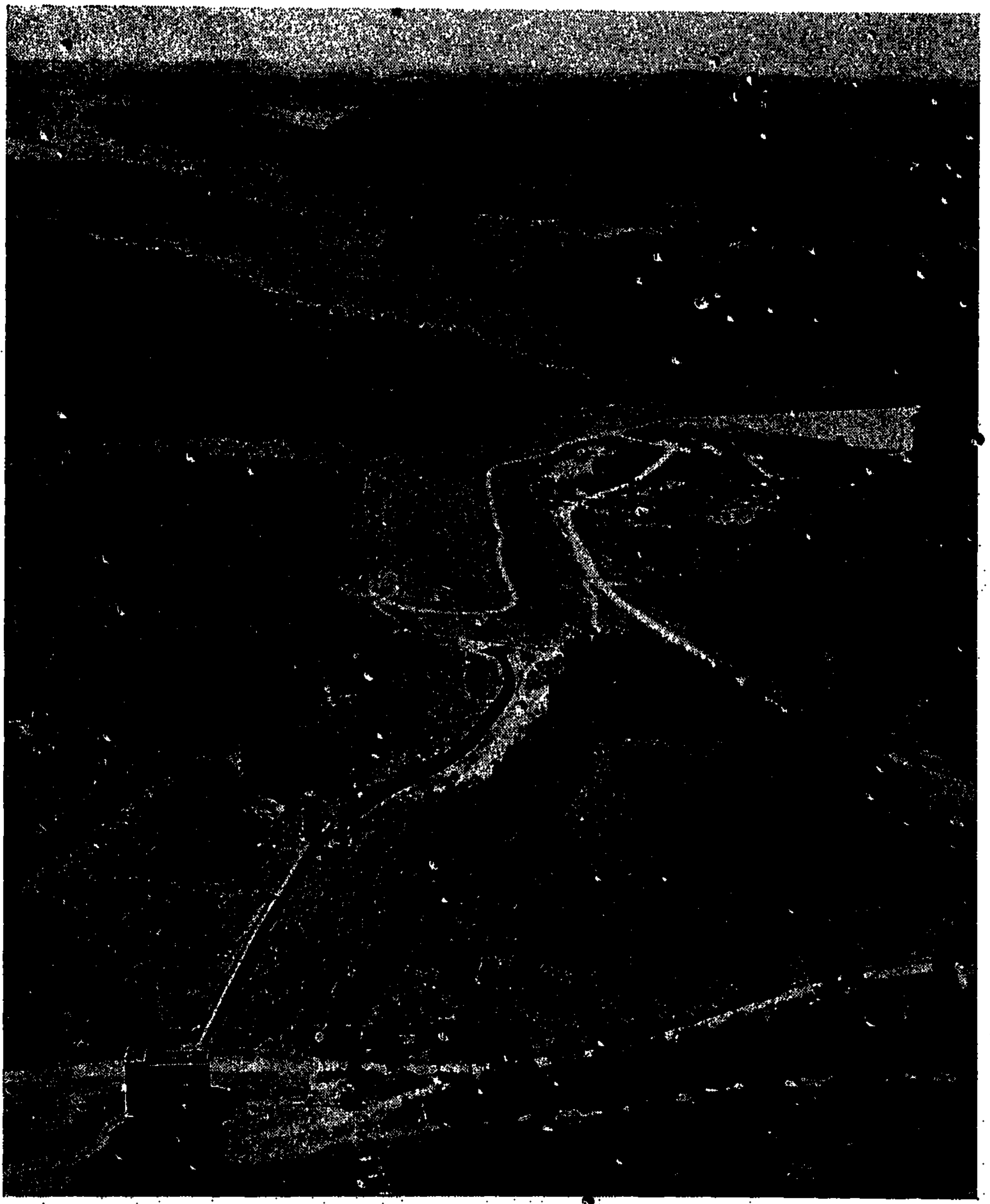

**Fig. 3. Rocky River plant of the Connecticut Light & Power Company at the junction of the Rocky and Housatonic rivers near New Milford, Conn., the only major pumped storage plant in the United States**

The plant is situated on the Housatonic River, being connected to the storage reservoir on the Rocky River by a single penstock which serves both the 30,000-kva turbine-generator unit and 2 8,100-hp pumps; provision is made for a second penstock at the Y-connection just beyond the surge tank. What appears as a black line just above the dam is a boom to protect the dam from wave action. The circular tower at the left end of the dam contains the trash racks and intake gate to the penstock. For a description of the development see A.I.E.E. Trans., v. 47, 1928, p. 1,100–07 incremental cost of hydroelectric capacity. For similar hydraulic conditions this second component, expressed in dollars per kilowatt, is almost constant except for major fluctuations in price levels and for differences in accessibility of the power site. Even over a wide range of hydraulic conditions it rarely will deviate more than 25 per cent from the average, which is approximately $60 per kw.

Considering the approximate constancy of incremental cost and the great variation of base cost, a full answer to the question whether a hydroelectric plant is a high or low cost development, cannot be given unless total power plant costs are segregated into these 2 components. For purposes of illustration, the values used in Figs. 4 and 5 have been selected as representative averages for a low-head pondage-equipped run-of-river plant, located on the eastern slope of the Appalachian range.

During the project stage, when only estimated and not actual cost figures are available, this approximate division of cost may be obtained by plotting against kilowatts of installed capacity as abscissa the estimated cost for the minimum capacity ($C_{min}$) as well as for the maximum capacity ($C_{max}$) under consideration. The point of intersection of a straight line, drawn through these 2 points, with the axis of cost will give the approximate value of the base cost component. As certain structural provisions usually must be made initially to permit expansion to a larger ultimate capacity the actual cost of the minimum capacity installation ($C_{min}$) will be somewhat higher than the estimated cost of minimum capacity exclusive of these provisions for future expansion.

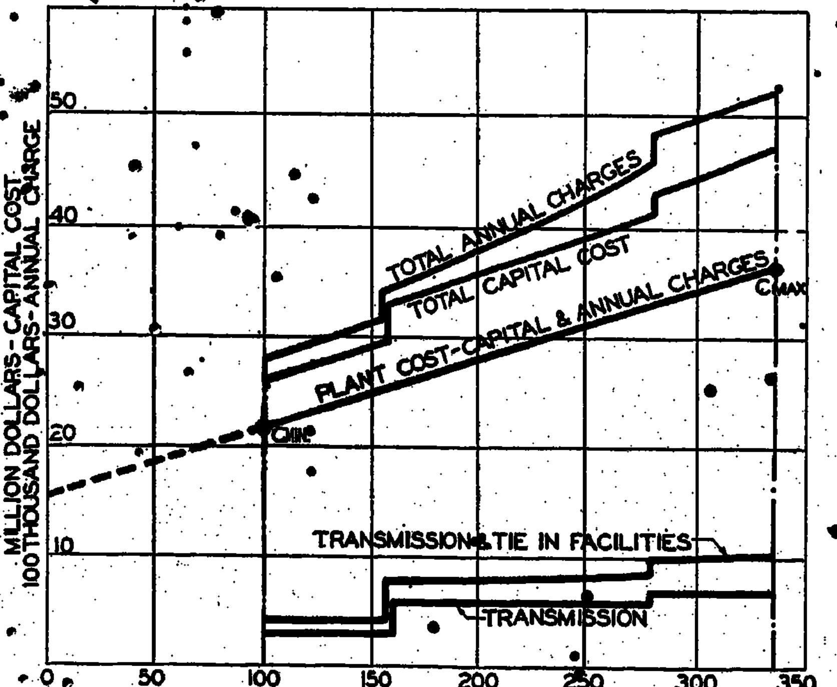

Fig. 4. Analysis of the cost of a hydroelectric project

The vertical scale in Fig. 4, representing capital cost, can be converted readily into a proportionate scale of annual charges, for the sum total of interest charges, taxes, depreciation, operation, maintenance, and other expenses, is approximately proportionate to investment. In Fig. 4 the over-all rate has been assumed at 10 per cent, based upon an average return of approximately 7 per cent on investment. Depending on the method of financing, this over-all rate may be reduced somewhat especially during the initial years.

The sum of the first 2 components represents the cost of the power plant proper, controlled largely by the hydraulic characteristics of head and discharge and by local conditions at the power house site and along the shores of the pond or reservoir. The other 2 components of cost, transmission and tie-in investments, are controlled by the geographic location of the plant in respect to its potential market, and by the opportunities of effecting a physical tie-in to existing lines or distribution networks at a minimum cost. Although bearing hardly any relation to plant costs, yet these 2 components must be fully considered as cost elements for hydroelectric power. It is not infrequent that a low cost and in every other way seemingly ideal project is uneconomic by reason of excessive transmission and tie-in cost. Conversely, certain other projects may be favored by short transmission distances to load centers, nearness of existing high voltage lines, and advantageous location of step-down stations in respect to city distribution systems.

In some special cases these 2 components of costs may become a credit rather than a charge. If, for example, a large power consuming industry is so close to the power site that it can be served economically at generating bus voltage, there will be a saving in transmission cost compared with supplying power to that industry from a more distant source; or if nearby railroad lines are electrified, there may be a distinct saving in tie-in expense not only because of the nearness of the electrified tracks, but also because where the railway operates from a 25-cycle single-phase system, lower speed single-phase generators can be used instead of the customary frequency converting equipment required in connection with 60-cycle steam power. These cases are exceptional rather than average; as a rule, the combined cost of transmission and tie-in investment will appear as a charge rather than a credit for hydroelectric power. Especially where long distances are involved, such as Boulder Dam or the St. Lawrence development, the cost of these 2 components may be equal to or exceed the increment cost per kilowatt of installed hydroelectric capacity. Development of 230-kv transmission has a tendency, where large amounts of power are involved, to reduce the transmission cost for a given distance, but to increase slightly the tie-in cost.

As extensions are made at the hydroelectric plant the cost of transmission will increase in sharp steps corresponding to the building of additional transmission lines, but the tie-in costs usually will grow at a gradual rate, corresponding to the step-by-step installation of additional underground cables and other tie-in equipment to keep pace with the increase in hydroelectric capacity. Annual charges for transmission and tie-in facilities will bear again a proportionate relation to the investment, but at a somewhat higher rate (12 to 15 per cent) than that used for the annual charges of the plant proper.

While it may appear academic to combine at an

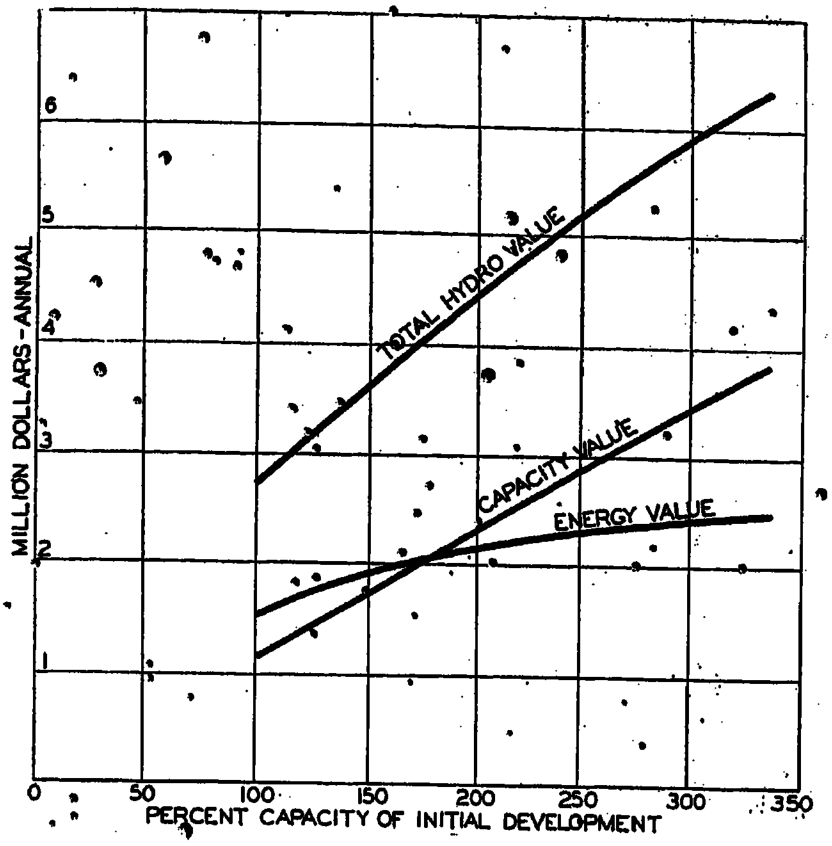

**Fig. 5. Analysis of the value of a hydroelectric project**

early stage of the project the estimated cost of the plant proper with the cost of transmission and tie-in facilities which are indirectly dependent upon marketing the power, yet a tentative forecast of these cost components is indispensable to a preliminary investigation of the economic justification of a project. Instead of adding these 2 components to the other costs of hydroelectric power, they could be subtracted from the composite value of the power, which is analyzed in the paragraphs that follow. This latter method, however, would not give as clear and convenient a graphic picture of the relationship of over-all cost and value.

## VALUE OF HYDROELECTRIC POWER

The generally accepted yardstick for evaluating hydroelectric power is the replacement cost of its 2 main components, capacity and energy, by the cheapest alternative source of supply—steam. Hydroelectric projects that have only a single potential market for their output, are more readily analyzed than those projects that have several possible outlets for power and the operation of which can be so coordinated with the operation of several steam plants that hydroelectric power renders the relatively most useful, and therefore the most valuable, service to the combined system.

Aside from the replacement value of water power as measured by the steam yardstick, a hydroelectric plant, by proper coordination of power house discharge, may add materially to the energy and capacity output of any plants located farther downstream. There are also several other collateral or contingent advantages of hydroelectric power which would be difficult to express in definite figures. Some of these features have been referred to in previous sections of this article dealing with the choice of water power or steam as a source of supply. For the purpose of this approximate analysis, however, all of these collateral features are omitted and evaluation of water power is confined to the 2 main components, capacity and energy.

It is evident that there can be credited toward the cost of hydroelectric capacity only an amount equal to the cost of equivalent steam capacity that would render a corresponding amount of firm peak service on a given system load, and that otherwise would have to be provided in the form of steam investment in order to insure adequate reserve capacity for the system. Strictly speaking, this definition would limit in the initial year the capacity value of a hydroelectric plant of any type to the annual increase in connected system load, or at the most, to the capacity of a single steam unit if the latter is larger than the anticipated increase in system load. This rather narrow definition gradually is giving way to the long range point of view, taking into account the average capacity value rendered over an extended period.

For a given amount of minimum flow energy, the amount of hydroelectric capacity that can render firm peak service to a system will increase gradually with the growth of system load, provided the load curve at least in its upper portion retains approximately the same shape. If additional load areas that previously supplied all of their requirements by steam can be tied in to a new hydroelectric plant the firm peak service rendered to the combined system will be increased materially. This is true provided, of course, that these new loads are similar in character to those originally served by the plant.

Capacity value per kilowatt comprises, in addition to the fixed charges—interest, depreciation, taxes, insurance, and some general expense—those items of steam plant operating costs that are more or less independent of the amount of power generated. This combined value varies somewhat in different localities. Aside from differences in price levels, it probably is more affected by the size of individual steam units than by any other single factor. Under

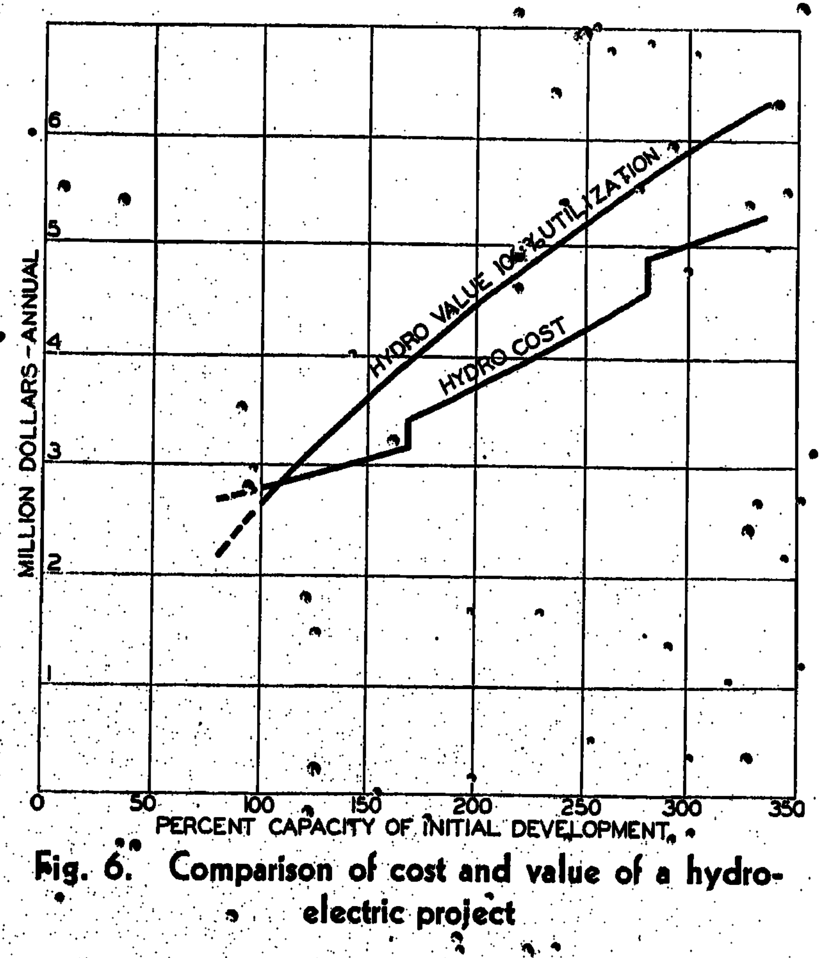

**Fig. 6. Comparison of cost and value of a hydroelectric project**

present conditions its lowest value is perhaps in the neighborhood of $10 per kw but in some instances exceeds $18 per kw for modern medium sized stations; the average is in the neighborhood of $13 which is the value used in Fig. 5.

The energy value per kwhr comprises, in addition to the cost of fuel and maintenance, only some minor items of operating supplies and labor. Depending mainly upon the price of fuel in the territory, upon the heat cycle of the station, and upon the relative size of boiler and turbine units, the energy value under present conditions may be assumed to vary (except for mine-mouth plants) from a minimum of around 2 mills per kwhr, or slightly less, to a maximum of around 3 mills, the average being perhaps 2.5 mills for unit capacities of 50,000 kw and higher. This latter value has been used for computing the total energy value of the hydroelectric project analyzed in Figs. 4 and 5, assuming full utilization of the water power available.

In order to approximate the effect of transmission losses, of capacity reductions by flood stage, drawdown of pond, etc., certain reductions have been applied to energy as well as to capacity. For less than full utilization of either installed capacity or available water power, the combined curve will drop below the values indicated, the amount of which reduction can be determined readily as a proportionate reduction of the respective component parts.

Composite curves of hydroelectric costs and values have been replotted in Fig. 6 to bring out more clearly certain trends frequently observed in connection with major hydroelectric projects serving a large interconnected load system supplied by water power and steam. During the initial years of operation, water power will compare less favorably with steam than during later years. However, a reasonable expectation is that a hydroelectric plant which has low incremental cost and not unduly high cost of transmission and tie-in facilities in the long run will yield a substantial margin of savings below the cost of steam. In addition, there will be several collateral advantages to its credit, which have been omitted in this graphic presentation.

# Metal Deposition in Electric Arc Welding

**Experimental work here reported indicates that liquid globules are the chief form of metal transfer in electric arc welding. A new method of high speed "recording" produces a metal record which can be compared directly with a corresponding oscillogram.**

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METAL TRANSFER is one of the most important functions of the electric welding arc. Whether the metal deposited passes through the arc as vapor, as mist, or as globules larger than mist, long has been under discussion; as also has been the nature of the driving force of transfer, particularly in overhead welding where the counteracting force of gravity must be overcome.

Some students of this phenomenon have thought that the larger part of the metal is transferred as vapor generated at the tip of the wire electrode and condensed in the crater formed on the object welded. Others, pointing out the large amount of energy required to vaporize the metal at the tip of the electrode, have reached the conclusion that the principal transfer must occur as mist or globules of molten metal. Some have attributed the driving force to the evolution, within the melting tip of the electrode, of gas which results in a succession of tiny explosions discharges particles of the metal. Still others have explained the transfer as resulting from the forces of adhesion and surface tension between the molten metal on the electrode tip and that in the crater when the 2 liquids touch each other.

Another theory recently revived cites the "pinch effect" as accounting for the force necessary to separate the globules from the electrodes. (This subject is reported at length by F. Creedy and, with discussions thereon, recorded, on p. 556–66 of the A.I.E.E. Trans., June 1932.—*Ed.*) Finally, this last theory has been supplemented by discussion which suggests that the globule is propelled from the electrode by the forces resulting from the tremendous current density existing in the neck or filament of metal formed just as the globule is being separated from the electrode.

Other experimenters have found that whereas they were able to do overhead welding with ordinary steel wire, they were unable to do it with a wire of pure iron free from gas. This would seem to indicate that the combined action of "pinch effect" and surface tension, or "pinch effect" and vaporization of the

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From, and presenting essential substance of, a paper presented at the Fall meeting of the American Welding Society, Buffalo, N. Y., Oct. 4, 1932.

pinched part of the conductor, is insufficient to transfer the metal against the force of gravitation without the help of the expulsive action of gas contained within the melting tip of the electrode.

All these experiments and theories emphasize the importance of the mechanism of metal transfer, and reveal the incomplete state of knowledge of its nature.

A partly successful attempt to record by high speed continuous photography the forms in which metal is transferred through the arc has shown that some metal is transferred as globules and some as threads. Instantaneous conditions revealed are shown in Figs. 1 and 2. This method, of course, would not show the metal which might be transferred as mist or as vapor.

## A New Method of Study Disclosed

In the welding laboratory of Lehigh University has been developed a new and direct method of investigating this subject of metal transfer, a method which records *all* of the possible forms in which metal is transferred through the arc. The principal feature of the method involves the moving of a highly polished metallic strip under the arc at a speed sufficiently high to enable each successive deposit of metal to be made on the strip distinctly separated from the others. The metal strip, or metallic mirror, thus gives a continuous and chronological record of the character of the deposit, and each form retains its identity and is easily recognized, whereas in ordinary welding the globules, mist, and vapor merge in the molten crater and lose their identity at once.

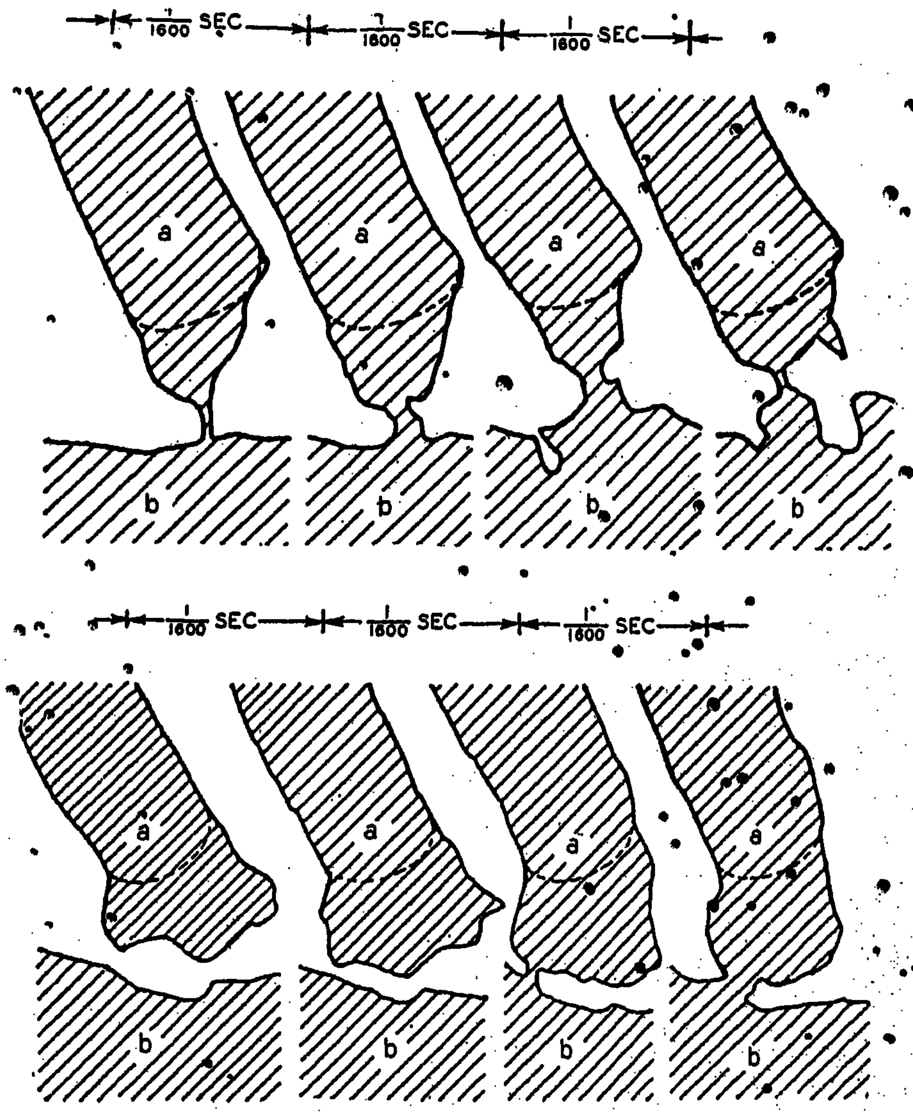

**Fig. 1. Instantaneous conditions in the transfer of metal by means of the electric arc; above, thread shaped transfer; below, mushroom shaped globules**

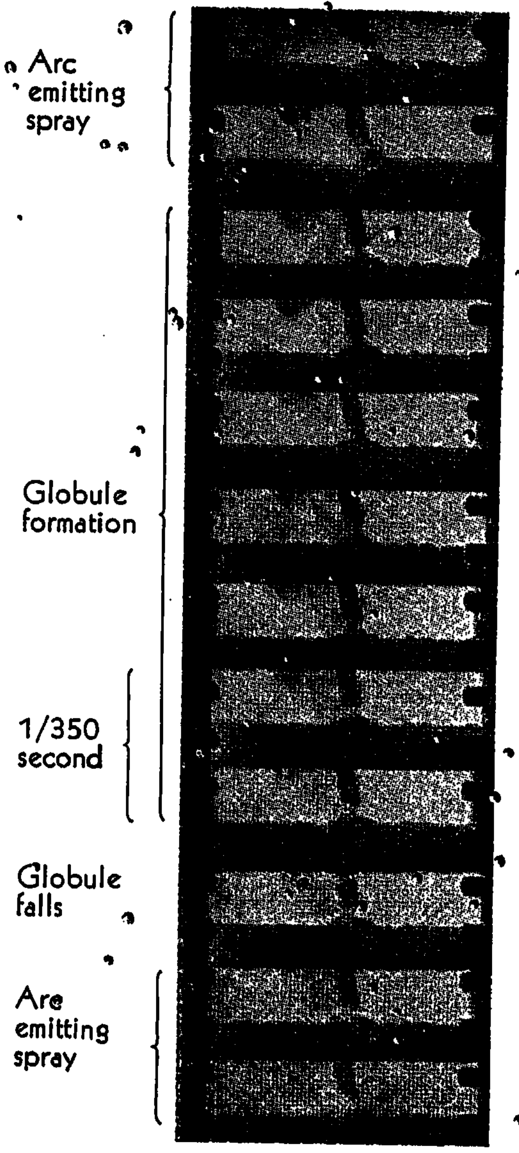

**Fig. 2. Thun's high speed photography showing a cycle in electric deposition**

In the Lehigh experiment a polished strip of mild steel 4 x 36 x $^1/_4$-in. in dimensions was run through an automatic welding machine at a rate of speed in excess of 100 in. per min, using a $^5/_{32}$-in. mild steel wire, a current of 150 amp, and somewhat more than 20 volts across the arc. The energy was supplied from a standard arc welding motor generator set. Results as shown in Fig. 3, where it may be noted that the flattened globules ranging between $^1/_{16}$ and $^3/_{16}$ in. in diameter at the base, clearly are shown to form the major portion of the deposit. Many of these show a gas cavity caused by the escape of dissolved gas as solidification took place. Under the conditions of this experiment, any vapor was oxidized before deposition and appeared on the strip as a red powder. The particles of spray also were oxidized, although probably only to $Fe_3O_4$, as a result in the decrease of surface-to-volume ratio in the larger spheres. To condense these two forms of deposition unoxidized the air about the arc would have to be replaced by an inert gas such as argon. Examination indicates that, in this case, the amount of material deposited in these forms was considerably less than 10 per cent of the total deposit; and that the chief form of transfer was as liquid globules.

Conditions involved in this test differ, of course, in some respects from those of ordinary welding. For instance, the heating of the strip under the rapidly advancing arc is insufficient to cause crater formation. Surface fusion does take place, however, beneath each globule, even at this speed, as examination shows the globules are tightly welded to the plate and resist removal by the chisel. Therefore, the temperature of the strip under the arc has been at least 1,500 deg C (the melting point of steel). A temperature considerably higher than this (probably 2,450 deg C, the boiling point of iron) exists at the crater in normal welding and therefore more heat is radiated from the crater to the wire tip, but the amount of heat so radiated to the globule on the tip of the electrode, as calculated by the Stefan Boltzman law, seems to be less than 10 per cent. This would not be sufficient to vaporize any considerable proportion of the globule before it left the wire, and thus would not change appreciably the proportion deposited as globules. The conditions of this test thus are at least enough like those of ordinary practise to render them suitable for comparative investigation of the basic phenomena of deposition.

Oscillographic records of the instantaneous values of current and voltage of the arc accompanying each series of depositions were taken on a 6-ft film, a section of which is reproduced in Fig. 3 where the deposit accompanying each current peak on the film is shown below its own peak. The accuracy with which the oscillogram records the operation of the depositing mechanism is striking. The size of the current disturbance on the film corresponds quite well with the size of the globule deposited on the strip. For instance, the overlapping globules at the extreme right correspond to the group of current peaks on the film above it, and the same correspondence holds for the double globule near the center of the series. The tiny globules of spray seemed to bridge the arc sufficiently to give a voltage "zero," although the time was too short for appreciable growth of current. This voltage zero indicates that the deposition was not entirely a spraying process even for these tiny globules. The same momentary voltage zeros appear in several other places where spray is found.

The globule next to the left of the sprayed group (in the direction of motion) illustrates the simplest case, a single globule and a single current peak and voltage valley. Likewise, the next to the left shows a double globule and double peak, but its neighbor (third from left) and also the second one from the left, both show more peaks than globules, due perhaps to complete merging of the globules before solidification.

It may be interesting to note that the largest peak of a group is nearly always the first one, possibly indicating the transfer of accumulated liquid at the tip of the electrode. Also, one notes that between the peaks of a group the voltage rises to full arc voltage, with a very short overshoot of voltage above normal, whereas the current in the valleys between peaks does not drop fast enough to reach the normal current value in the short interval. The ordinary ammeter and voltmeter used in welding show, of course, only the average current and voltage, and do not show these rapid fluctuations.

In general, the correspondence between metal deposition and oscillographic record is surprisingly accurate. Eleven other complete strings of globules with oscillograms to accompany them were made, using a variety of electrodes, currents, and speeds, each with the general results the same as described.

## CONCLUSIONS

These experiments indicate that liquid globules are the chief form of metal transfer, although there is some metal transfer as vapor and mist. A close correspondence is seen between the individual types of deposit and the individual features of the current and voltage waves on the corresponding oscillogram. The oscillogram would seem to be a trustworthy indicator of the depositing mechanism.

This method, revealing as it does the mode of metal deposition, offers also a means for testing and comparing the depositing performance or so-called "weldability" of various types of electrodes. The results of tests of this kind may be interpreted, moreover, both for hand and for automatic welding.

These results are for "bare," or very lightly coated, electrodes. The modern heavily coated electrode, because of its chemical protection to the metal in the arc, can and does use a longer arc length, in fact, so long that the globules are unable to bridge the arc and to cause the current peaks and voltage zeros of "short arc" welding. Globules are believed, however, to be the chief form of transfer, also when the longer arc and coated electrode are used. This question could readily be decided by the use of the method described in this paper, using heavily coated electrodes.

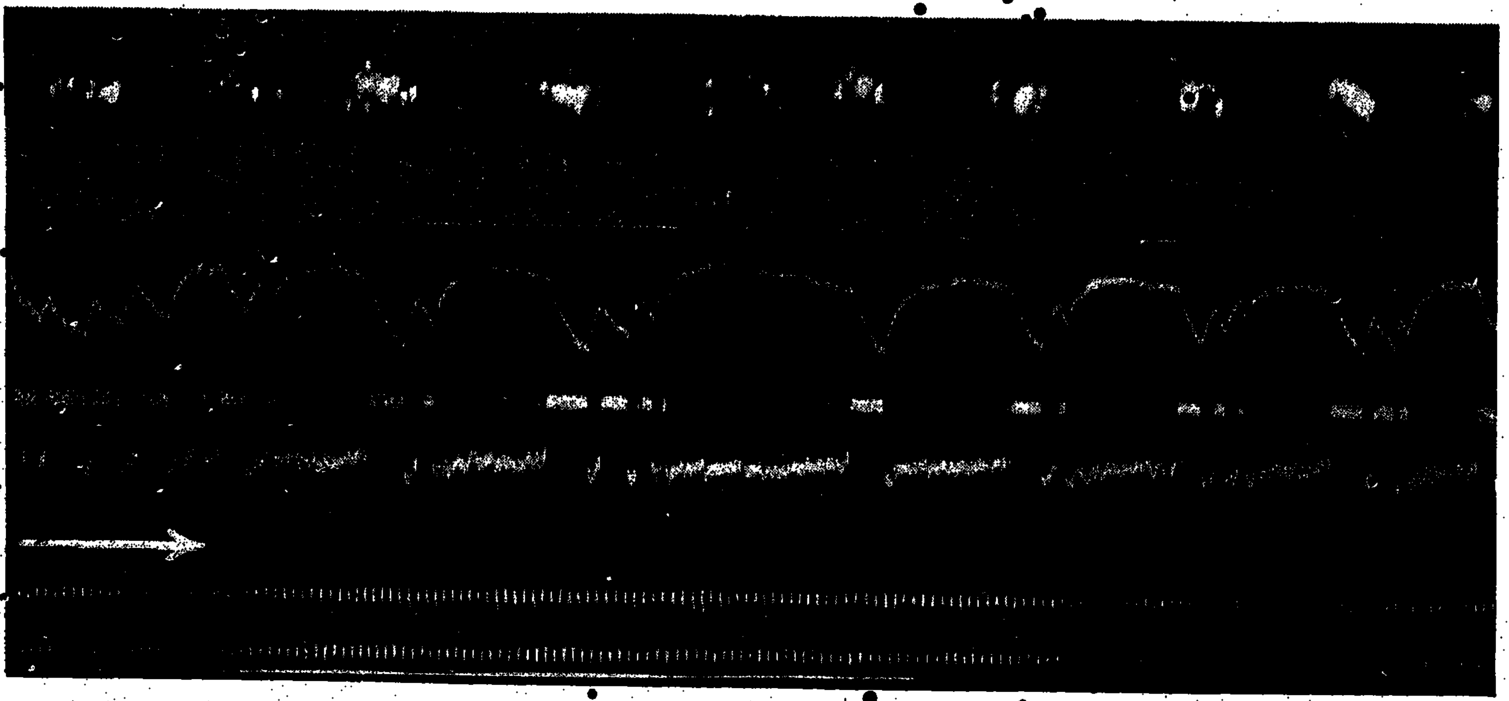

Fig. 3. Composite reproduction showing a section of the high speed metal "record" of actual deposition, and the relation of the various deposits to the corresponding oscillogram

# Synchronous Motors in Rolling Mill Service

Improvements in the synchronous motor and its control, together with a growing recognition of its favorable first cost and operating characteristics, have resulted in its rapidly increasing application to constant speed main-rolls in metal-rolling mills, both steel and non-ferrous. A brief review of the present status of such applications, and some important controlling factors are given here.

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AT THE BEGINNING of 1932 there were 161 synchronous motors totaling 231,950 hp driving main-rolls in steel mills and in copper, and brass, and other non-ferrous mills. This amount of horsepower is small compared to the total in use on metal-rolling mills, nevertheless it represents the largest part of the horsepower in constant speed motors installed since synchronous motors have been developed for main-roll drives. The types of main-roll drives to which synchronous motors are applied and the number of units and horsepower installed are shown in Table I.

These units range in speed from 900 to 62 rpm; about $^1/_5$ operate at 25 cycles, the remainder at 60 cycles; approximately $^1/_3$ are direct connected and $^2/_3$ are geared to their mills; voltages range from 220 to 11,000 inclusive.

## REQUIREMENTS AND SCOPE OF APPLICATION

In the field of constant speed rolling mill drives, the only apparent limitation to the use of synchronous motors is on those mills having heavy passes of short duration where it is practise to interpose fly-wheels between the load and the line. However, with the present large and growing capacity of power systems supplying most rolling mills, the need of protecting the line from short-time high-peak loads becomes of decreasing importance and the elimination of flywheels is a desired step toward greater drive simplicity. Several synchronous motors now are applied successfully to main-rolls, such as plate mills, where motors with flywheels formerly were considered essential.

On large reversing mills, synchronous motors must be excluded from consideration because frequent and rapid reversal is one of the important requirements. On certain smaller mills, however, where relatively slower reversal and constant speed rolling are satisfactory, synchronous motors offer possibilities. One continuous-reversing synchronous motor now is in use driving a copper break-down mill.

The torque requirements for various types of main-rolls are given in Table II. Except for cold-roll mills, the starting and pull-in torque requirements under normal starting conditions are comparatively light, 50 per cent of the full load torque of the motor usually being ample. Emergencies, however, may require the mill to be reversed or jockeyed under load. Hence, starting and reversing torques ranging from 85 to 100 per cent must be available, secured by applying a higher percentage of full voltage, or full voltage to the motor in starting. Cold-roll mills, because of the very high friction load, require high starting and pull-in torques. The pull-out torque requirements will be determined, of course, by the type of load imposed by the particular mill, with the highest values in general for those mills where rolling is intermittent and the passes are short.

Rolling mills, although similar in the main features of their construction and operation, nevertheless vary considerably in their individual load characteristics and motor requirements. In Table II the approximate torque requirements for specific mills have been set up. This tabulation also presents some approximate data on motor ratings and the load characteristics of mills which afford opportunity for application of synchronous motors. Additional comments on the groups of mills shown in Table II are given in the notes appended to the table. By graphical kilowatt charts Fig. 3 depicts the important types of rolling loads encountered.

## MOTOR CHARACTERISTICS

Values of starting and pull-in torques available in synchronous motors of normal design vary considerably, depending upon the horsepower, speed,

**Table I—Applications of Synchronous Motors to Main-Roll Drives**

| Mill | Units | Hp | Avg Hp |
|---|---|---|---|
| Billet and bar mills | 21 | 74,750 | 3,500 |
| Tube piercing mills | 20 | 41,300 | 2,000 |
| Copper and brass mills | 47 | 25,450 | 550 |
| Rod mills | 10 | 21,850 | 2,200 |
| Tube rolling mills | 8 | 11,600 | 1,400 |
| Skelp mills | 2 | 10,500 | 5,000 |
| Hot strip mills | 11 | 14,950 | 1,350 |
| Merchant mills | 11 | 9,900 | 900 |
| Tube reeling and sinking mills | 9 | 4,250 | 450 |
| Structural mills | 1 | 3,000 | 3,000 |
| Tinplate mills | 2 | 3,000 | 1,500 |
| Cold-roll sheet mills | 5 | 2,500 | 500 |
| Rail rerolling mills | 3 | 1,800 | 600 |
| Cold-roll strip mills | 2 | 1,000 | 500 |
| Plate mills | 1 | 1,000 | 1,000 |

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Prepared especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

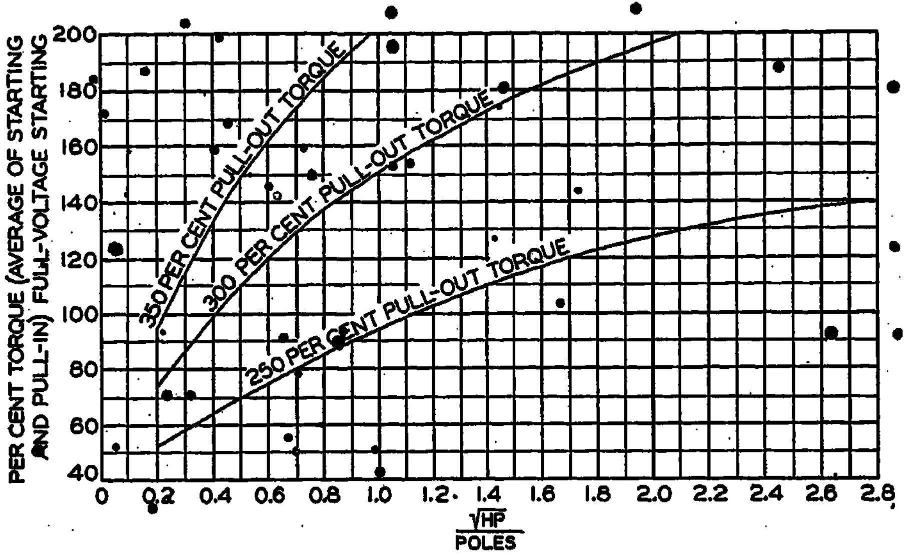


Fig. 1. Approximate relationship of starting and pull-in torque to motor horsepower, speed, and pull-out torque ratings for 60-cycle synchronous motors operating at 0.8 power factor and at speeds of 450 rpm or lower

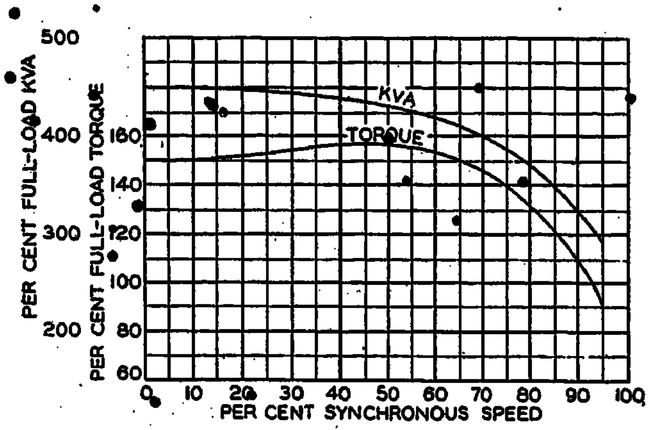
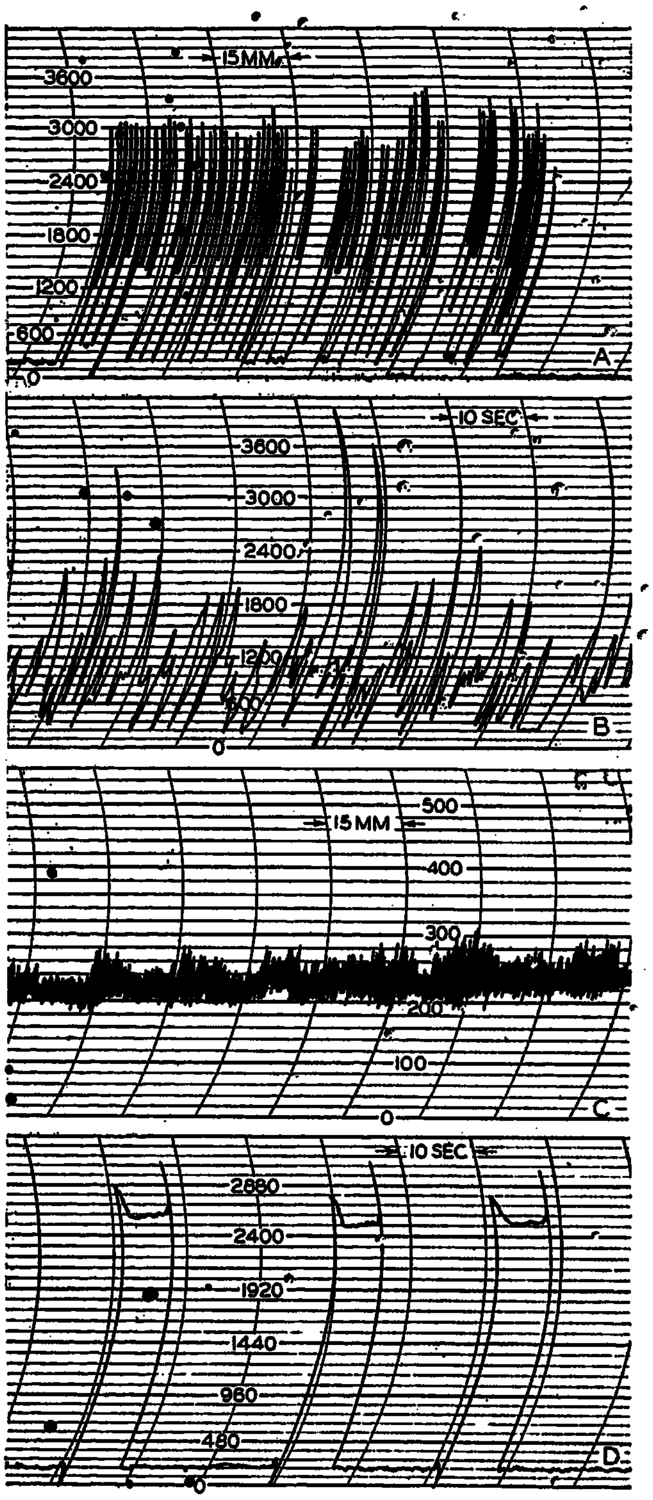


Fig. 2. Starting torque and kva curves for 3,000-hp, 450-rpm, 60-cycle synchronous motors operating at 0.8 power factor (calculated values)

rating, and pull-out torque for which any individual motor is designed. For purposes of illustration, the relations for motors of 0.8 power factor are shown approximately by the empirical curves of Fig. 1. These curves are for 60 cycles, and speeds of 450 rpm and lower. For 25-cycle motors the approximate relationship of starting and pull-in torque to motor horsepower, speed, and pull-out rating, can be derived from Fig. 1, for 0.8 power factor, by multiplying the 25-cycle motor horsepower by 2.4 to locate the desired point on the abscissa.

As illustrated by Fig. 1, an average of starting and pull-in torque in excess of 100 per cent is available inherently over a wide range of horsepowers and speeds, especially for higher values of pull-out torque. For low 60-cycle speeds, where full-load starting torques are not inherent in a normal design, they can be secured by increasing or changing the proportions of active material in the motor. Moreover in all cases, considerable latitude exists in the design of the induction-motor characteristics of the synchronous motor, so that individual values of starting torque and pull-in torque can be varied from the average to provide a torque curve most suitable to meet the requirements of main-roll drives. Pull-out torque requirements for main-roll drive can be secured more easily and less expensively in synchronous motors designed for operation at 0.8 power factor than in those designed for operation at unity power factor. From the standpoint of pull-out torque, therefore, motors operating at 0.8 power factor are preferable.

"Field-forcing" for increasing the field excitation to values above nominal to provide higher pull-out torque during the periods of peak loads, has interesting possibilities in providing for more economical applications on mills with high, but relatively infrequent peak loads. At present, so far as is known, its use is limited because of limitations in the quickness of response to sudden load increases. It is applicable now to drives where increase in load is comparatively slow, or where the load increase can be anticipated either by the mill operator or by trip switches actuated by the metal entering the mill.



10-stand 18-in. billet mill reducing 7 x 6 in. blooms to 2 x 2-in. billets. 5,000-hp 514-rpm motor

8-stand tinplate mill. 2,000-hp 300-rpm synchronous motor

10-stand cold-roll sheet mill. 500-hp 514-rpm motor

Seamless tube mill rolling pipe of approximately 10-in. diameter. 1,500-hp 86-rpm motor

Fig. 3. Kilowatt charts showing nature of power demand met by various synchronous motors

Under normal conditions of starting, except for cold-roll drives, the torques required to break the mill from rest and accelerate it usually are available with a power inrush not exceeding 175 per cent of the full-load kva of the synchronous motor, secured by using one of the various methods of reduced-kva starting. For emergency starting and reversing, where starting torques higher than normal are necessary, the power inrush, of course, will be larger.

The kva starting demand of a synchronous motor, particularly in the larger mills, has become a factor of less critical importance than formerly. As a result, starting at full voltage, with attendant high kva inrush, can be tolerated in many instances to simplify both the starting operation and the starting equipment.

Starting characteristics of a 3,000-hp, 450-rpm, 0.8-power-factor, 60-cycle, main-roll synchronous motor are shown in Fig. 2. A starting torque of 150 per cent, with a starting kva of 450 per cent, is obtained with full-voltage starting. However, a starting torque of 50 per cent normally is ample for starting the mill and with this torque the starting kva is but 150 per cent of full load kva.

In the application of a synchronous motor to a main-roll drive, the inherent characteristics of the motor are such that several factors each must be considered individually. Although in this article an attempt has been made to set forth the general requirements, they should not be considered as ready-made rules which can simply be lifted out and used; good application engineering, with due recognition of the motor's shortcomings, is required at all times. In every case the motor must be designed and built with quite an exact advance knowledge of the mill requirements, necessitating close cooperation between engineers of the mill and of the motor manufacturer.

## NOTES ON TABLE II

1. Types of mills listed are those which afford opportunity for synchronous motor drive, and in general they are the types most frequently used.
2. Motor horsepower and speed limits are approximate.
3. See kilowatt charts of Fig. 3 for graphical depiction of load characteristics for some of these mills.
4. Torques are given as a percentage of the full load torque of the motor, and are based on the average horsepower required for the type of mill. Increase or decrease in horsepower will modify the torque percentages. Torques shown above apply regardless of type of starting used.
5. Lower values of starting torque shown usually are ample to start the mill unloaded, but the higher torques shown must be available.
6. Both 3-high, and continuous billet and bar mills offer suitable and advantageous applications for synchronous motor drives; many such mills now are so driven. Because of the relatively limited, large sections rolled by these mills, speed flexibility usually is not of primary importance, and a constant speed drive is satisfactory.
7. For the roughing and intermediate stands of skelp, hot-strip, merchant, and rod mills, where the metal section is large and the rolling speed relatively slow, a constant speed drive generally is satisfactory and synchronous motors are applied to advantage. For the finishing stands, where the metal section becomes light, and elongation is rapid, adjustable speed motors usually are necessary.
8. Plate mills constitute somewhat of a border line case for synchronous motor application because of the high, short peaks encountered. Conditions permitting, the synchronous motor should prove an advantageous drive, particularly because its use would eliminate speed variation as a deterrent factor in controlling uniformity of gage in rolling. For the roughing and shaping stands used in rolling rails and structural shapes, synchronous motor drive is subject to the limitations imposed by high, relatively short load peaks. For the finishing stands, however, where constant speed is satisfactory, synchronous motor drive is quite suitable.
9. The severe loads imposed by sheet and tinplate mills (of the non-continuous type) are made up of heavy impacts of short duration while the sheet-bars are being broken down, and heavy drags of longer duration when the sheets are being finish-rolled. The largely unrelated operation of the various mill stands results in irregular loads wherein the ratio of average horsepower demand to peak demand may be quite high. Synchronous motors show attractive possibilities of effecting substantial economies and improvements in production when applied to sheet and tinplate mills to replace present induction motors. The constant rolling speed afforded by the synchronous motor is of particular importance in insuring greater uniformity of gage in rolling thin sheets, and in eliminating variable speed as a factor in controlling mill production.
10. Cold-roll sheet mills also provide an attractive application for synchronous motor drives. The high friction load, together with the diversity of operation incident to the use of a single motor to drive several individually fed mill-stands, results in regular load and high load factor. High load factor enhances the economies of the high efficiency operation of the synchronous motor.
11. The load characteristics imposed by mills for making seamless tubes are somewhat alike. As the metal enters the mill, the load rises at once to its full value, remains almost constant at full value for the duration of the pass, then drops back immediately to no-load value. These passes vary in length from approximately 5 to 20 sec and are repeated from 2 to 4 times per minute. Except in the case of certain expanding mills and some reeling mills, a single

### Table II—General Mill Characteristics and Torque Data for Synchronous Motors Applied to Main-Rolls

| Application | Types of Mills[1] | Motor Horsepower[2] | Motor Speed[2] | Connection to Mill | Load Characteristics[3] | Torques[4] (per cent) Starting[5] | Pull-In | Pull-Out |
|---|---|---|---|---|---|---|---|---|
| **Steel Rolling Mills** | | | | | | | | |
| Billet and bar mills[6] | Continuous or three-high | 1,000 to 7,000 | 80 to 600 | Direct drive, single reduction gear, or tandam gear set | Continuous mills: varying load, moderate peaks<br>Three-high mills: intermittent load, approx. 3 to 15 sec duration; high peaks | 50 to 100 | 40 | 250 to 350 |
| Skelp,[7] hot strip, merchant, and rod mills | Continuous | 1,000 to 7,000 | 80 to 600 | Direct drive, single reduction gear, or tandem gear set | Varying load, moderate peaks | 50 to 100 | 40 | 225 to 300 |
| Plate,[8] rail, and structural mills | Three-high | 1,000 to 7,000 | 80 to 600 | Direct drive, or single reduction gear | Intermittent loads, approx. 1 to 15 sec duration; high peaks | 50 to 100 | 40 | 250 to 350 |
| Sheet and tinplate mills[9] | Two-high trains | 1,000 to 3,000 | 240 to 450 | Single reduction gear | Continuous, irregular load, frequent high peaks | 50 to 100 | 40 | 300 to 450 |
| Cold-roll sheet mills[10] | Two-high trains | 500 to 750 | 240 to 450 | Single reduction gear | Continuous, regular load | 150 to 200 | 100 to 150 | 250 |
| Seamless tube piercing mill | Mannesmann or Stiefel | 1,000 to 5,000 | 150 to 250 | Direct drive, or single reduction gear | Intermittent loads, approx. 6 to 30 sec duration; high peaks. On rolling mills load duration may not be more than 3 to 4 sec. | 50 to 100 | 40 | 250 to 350 |
| Rolling mills | Two-high | 1,000 to 2,000 | 62 to 83 | Direct drive | | | | |
| Reeling, sizing, and sinking mills | Two-high | 350 to 600 | 450 to 600 | Single reduction gear | Intermittent loads, approx. 6 to 30 sec duration; peaks moderate | | ... | 250 to 300 |
| **Copper, Brass, and Other Non-Ferrous Mills** | | | | | | | | |
| Breakdown mills[12] | Two- or three-high | 300 to 1,500 | 250 to 450 | Single reduction gear | Intermittent loads, approx. 1 to 15 sec duration; peaks moderate | 50 to 100 | 40 | 250 |
| Finishing mills | Two- or three-high | 250 to 600 | 250 to 450 | Single reduction gear | Intermittent loads, approx. 5 to 15 sec duration; peaks moderate | 50 to 100 | 40 | 250 |

speed drive is sufficient and the absolutely constant speed provided by the synchronous motor even at high overloads is a factor of considerable importance in making the tube. Also, the first cost and the high power factor and high efficiency at the comparatively slow speeds of these mills have caused the synchronous motor to be used widely for seamless tube mill drive.

12. Synchronous motors have been quite widely applied to non-ferrous breakdown and finishing mills. The power factor correction obtained for synchronous motors is of considerable importance in some plants, offsetting the low power factor characteristics of the induction furnaces used for melting.

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# Thermal Transients and Oil Demands in Cables

**Simplified solutions now may be obtained for the thermal transients and oil demands in power cables, due to load variations of any complexity whatever. Mathematical and graphical aids have been developed which greatly reduce the time and labor required for numerical work, and the theory has been verified by measurements on actual cables of the ordinary and oil filled types.**

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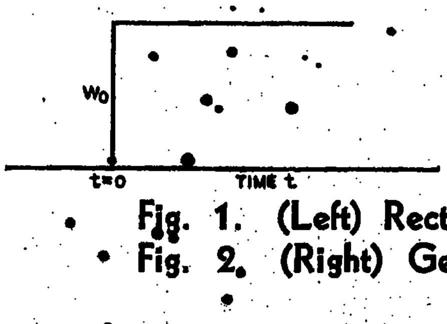
SINCE underground power cables almost always operate under variable loading, it is desirable to be able to establish their allowable carrying-capacities on the basis of variable loading, rather than on the basis of some equivalent steady state loading, as is the present practise. For this purpose it is most useful to know what temperature variations will occur at any point in the cable at any time due to an abrupt change from one constant load to another. Any load curve then can be handled with sufficient accuracy by breaking it up into a series of rectangular steps, and adding with proper time intervals the successive thermal transients.

The fundamental equations were developed several years ago, but the numerical solution was too complicated and laborious to be of general practical value. A simplified method is presented here, which employs calculating charts and other devices permitting complete exact solutions to be obtained in less than 20 per cent of the time formerly required. In addition to temperature transients due to abrupt load changes, precise simplified solutions for the following related phenomena are given:

1. Oil demands due to abrupt load changes in oil filled cables

2. Temperature transients and oil demands due to load variations of any kind, whether abrupt or otherwise.

Although the methods described in this paper were developed for problems of single conductor cables, they can also be applied directly to 3-conductor cables, using a per phase basis (*e.g.*, sheath thermal resistance = $3E$, etc.). For 3-conductor oil filled shielded cable with round conductors, the accuracy will be excellent. If the conductors are sector-shaped, good accuracy may be obtained by using the equivalent round conductors. For ordinary 3-conductor cable with solid fillers and no shielding, the accuracy will be only fair.



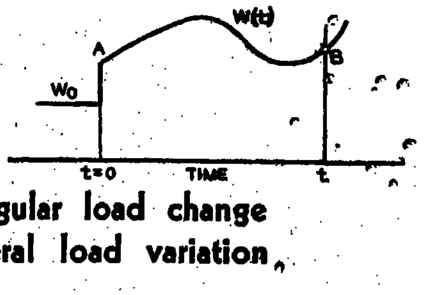


Fig. 1. (Left) Rectangular load change
Fig. 2. (Right) General load variation

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Based upon "Thermal Transients and Oil Demands in Cables" (No. 32-127) presented at the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., October 10-13, 1932.

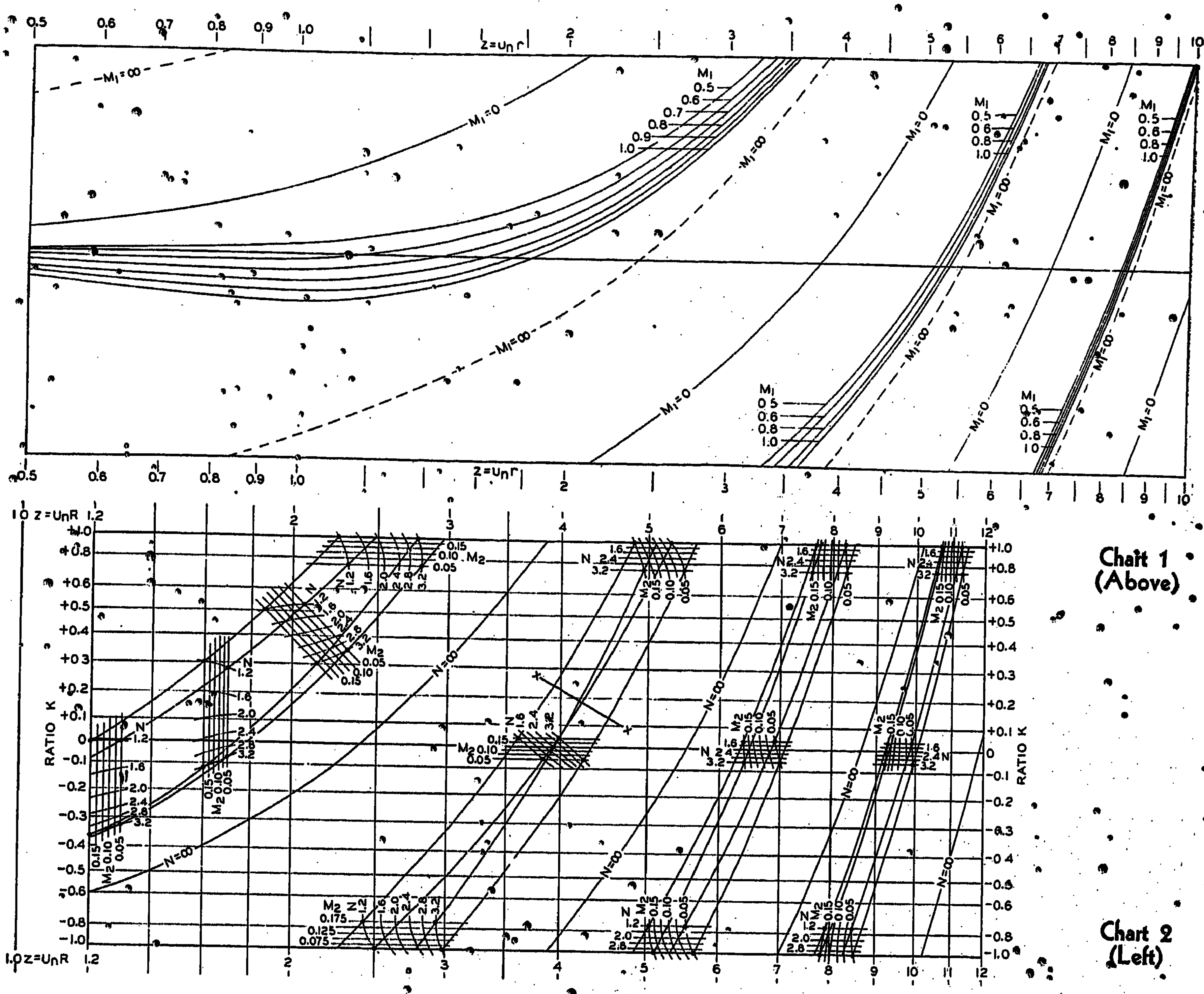


Chart 1 (Above)

Chart 2 (Left)

## SOLUTION FOR ABRUPT LOAD CHANGE

For any abrupt load change such as illustrated in Fig. 1 the equation for the temperature at any point $x$ in the cable at any time is:

$$T = \sum^{n} e^{-\lambda_n t} C_n F_o (u_n x, K_n) + \frac{W_c''p}{2\pi} \log \frac{R}{x} + \frac{W_i''p}{4\pi \log \frac{R}{r}} \left(\log \frac{R}{x}\right)\left(\log \frac{Rx}{r^2}\right) + (W_c'' + W_i'' + W_s'') E + T_o \tag{1}$$

where $\lambda_n = u_n^2/pq$

(For notation see List of Symbols)

For conductor temperature, $x$ is replaced by $r$, and for sheath temperature by $R$. The component oil demands contributed by shrinkage of the conductor, sheath, and insulation are, respectively:

$$a_1 = \frac{Cc}{pq} \sum^{n} u_n^2 e^{-\lambda_n t} C_n F_o (u_n r, K_n) \tag{2}$$

$$a_2 = \frac{Vv}{pq} \sum^{n} u_n^2 e^{-\lambda_n t} C_n F_o (u_n R, K_n) \tag{3}$$

$$a_3 = \frac{2\pi\epsilon}{pq} \sum^{n} e^{-\lambda_n t} C_n [F_1 (u_n R, K_n) - F_1 (u_n r, K_n)] \tag{4}$$

### Instructions for Using Charts 1 and 2

1. Lay Chart 2 over Chart 1 so that the Z axes coincide, and Z = R/r on Chart 2 coincides with Z = 1 on Chart 1.
2. Interpolate on Chart 1 the sequence of curves for $M_1$ and interpolate on Chart 2 the sequence of curves for $M_2$, N.
3. Note the points where intersections occur between the interpolated curves of Charts 1 and 2. Three intersections are sufficient.
4. For the n points of intersection, read off $K_n$ from the vertical scale. Also read off $Ru_n$ and $ru_n$ from the horizontal scales of Charts 2 and 1, respectively, starting at the left.

Note: In printed copy where Chart 2 is not transparent or removal permitted, it is convenient to trace the z axis, the interpolated P curve for desired value of $M_1$ and sufficient identifying abscissas z from Chart 1, on transparent paper, and to lay this tracing over Chart 2 with proper horizontal shift R/r (to the right), after which intersections may be found as already described.

and the total oil demand is:

$$a = (a_1 - a_2 + a_3)$$

The values of $u_n$ and $K_n$ are obtained from $n$ successive intersections (3 are generally sufficient) of the curves of Charts 1 and 2, which are entered

## Table I—Properties of Cable Materials

| Material | Specific Gravity | Weight lb/cu in. | Joules/cu cm/°C | Joules/cu in./°C | Joules/lb/°C | Thermal Resistivity °C/watt/cu cm |
|---|---|---|---|---|---|---|
| Water | 1.00 | 0.0361 | 4.18 | 68.6 | 1900 | 171 |
| Copper | 8.95 | 0.3230 | 3.44 | 56.4 | 175 | 0.285 |
| Lead | 11.37 | 0.4110 | 1.43 | 23.4 | 57 | 2.990 |
| Transformer oil | 0.90 | 0.0325 | 1.90 | 31.1 | 957 | 611 |
| Dry paper | 1.41 | 0.0508 | 2.26 | 37.1 | 730 | 770 |
| Oil filled insulation | 1.15 | 0.0415 | 2.10 | 34.5 | 832 | 550 |

The weight of copper conductor is 3.15 lb and its thermal capacity 551 joules per deg C per circular-inch foot, as ordinarily stranded and cabled.
The weight of lead sheath is 15.5 *Dd* lb and its thermal capacity is 883 *Dd* joules per deg C per ft, where *D* and *d* are the average diameter and thickness in inches.

with values of $M_1 = \frac{Q_1}{2\pi q r^2}$, $M_2 = \frac{Q_2}{2\pi q R^2}$, $N = \frac{p}{2\pi E}$, and $\frac{R}{r}$. The functions $F_o(u_n x, K_n)$ are obtained from Chart 3. The functions $F_1(u_n x, K_n)$ are obtained from Chart 4. Values of $C_n$ are obtained from the following equation:

$$\sum^{n} - C_n F_o(u_n x, K_n) = \Delta W_c \frac{p}{2\pi} \log \frac{R}{x} + \Delta W_i \frac{p \left(\log \frac{R}{x}\right)\left(\log \frac{Rx}{r^2}\right)}{4\pi \log \frac{R}{r}} + (\Delta W_c + \Delta W_i + \Delta W_s)E$$

by evaluating all terms except $C_n$ for $n$ different values of $x$, and solving the resulting simultaneous equations. Values of $C_n$ should be calculated for unit change in copper loss, dielectric loss, and sheath loss separately. Eq 1, 2, 3, and 4 will then yield "unit" transients. These need be calculated only once for a given cable, since for any particular problem the unit transients can be proportioned and added together in any ratio and combination desired, which is the work of but a few minutes. All quantities, such as $p$, $q$, $R$, $W_o$, $c$, etc., in the expressions for temperature and oil flow transients are readily obtained from Table I, or by well known methods which require no explanation.

The oil flows obtained from eq 2, 3, and 4 will be slightly in error for the first few moments of the transient, because only a few terms in the infinite series are used in obtaining numerical values, and the neglected terms are appreciable when $t$ is very small. The following correct expressions should be used for the initial instant ($t = 0$):

$$a_1 = -\Delta W_c \frac{Cc}{Q_1} \quad a_2 = -\Delta W_s \frac{Vv}{Q_2} \quad a_3 = -\Delta W_i \frac{\epsilon}{q}$$

### Solution for General Loading

The rectangular solution is readily generalized almost by inspection, through a well known application of the superposition principle. For the entirely general load curve of Fig. 2, the general solution for temperature at any point $x$ is:

$$T = \sum^{n} C_n F_o(u_n x, K_n) L_n(W, t) + (W_c)_t \frac{p}{2\pi} \log \frac{R}{x} + (W_i)_t \frac{p}{4\pi \log \frac{R}{r}} \left(\log \frac{R}{x}\right)\left(\log \frac{Rx}{r^2}\right) + E(W_c + W_i + W_s)_t + T_a \qquad (5)$$

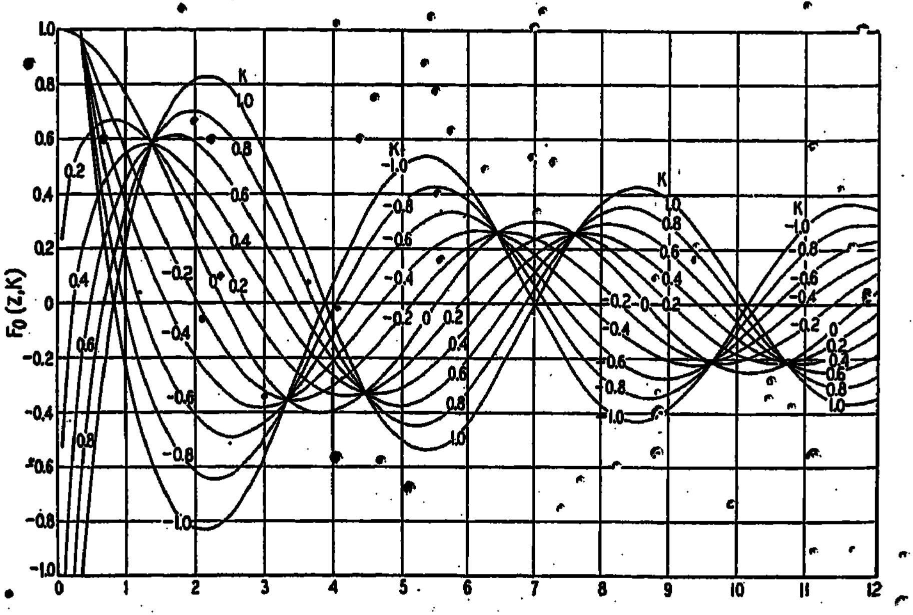


Chart 3. Functions F₀

The generalized oil flow equations are similarly obtained by substituting $L_n(W, t)$ for $e^{-\lambda_n t}$ in eq 2, 3, and 4.

The last 4 terms in the above equation differ from the corresponding terms in the rectangular solution only in that instead of using the constant watts lost after the transient, indicated by the superscript ($''$), the variable watts loss during the transient, indicated by subscript ($t$), is used, as explained below. The summation term is identical with the corresponding term in the rectangular solution, except that $L_n(W, t)$ is substituted for $e^{-\lambda_n t}$. The load function $L(W, t)$ is known as the Duhamel Integral, and for the present purpose is as follows:

$$L_n(W, t) = \left[\lambda_n e^{-\lambda_n t} \int_o^t (W_t - W_o) e^{\lambda_n t} dt - (W_t - W_o)\right]$$

Where the losses $(W)_t$ can be expressed as a mathematical function of $t$, the integral can be formally evaluated. For practical load curves this is seldom the case, and graphical or step-by-step methods must be employed. For the step-by-step method the load function is easy to evaluate when rewritten in the following approximate form:

$$L_n(W, t) = \left[\lambda_n \Delta t e^{-\lambda_n t} \sum_{0}^{t} e^{-\frac{W_t - W_o}{\lambda_n t}} - (W_t - W_o\right] \qquad (6)$$

The expression under the summation sign is to be evaluated point by point up to time $t$ (or point $B$, Fig. 2), using equal finite intervals of time $\Delta t$ for the preceding period. For good accuracy, $\lambda_n \Delta t$ should not exceed 0.5, and it is best to use the average values of $(W)_t$ and $t$ for each increment term under the summation sign. $\lambda_n$ and $C_n$ are exactly the same as for the rectangular solution.

At the instant of an abrupt discontinuity in $(W)$, the values of $L(W, t)$ for use in temperature equations are:

$$\Delta L_{cn} = -\Delta W_c \qquad \Delta L_{in} = -\Delta W_i \qquad \Delta L_{sn} = -\Delta W_s$$

and for oil flow equations, the correct values of oil flow are calculated directly from:

$$\Delta a_1 = -\Delta W_c \frac{Cc}{Q_1} \qquad \Delta a_2 = -\Delta W_s \frac{Vv}{Q_2} \qquad \Delta a_3 = -\Delta W_i \frac{\epsilon}{q}$$

for the same reasons discussed in connection with the solution for rectangular load change.

## PRESSURE DISTRIBUTION IN INSULATION

The principal object or purpose of oil filled cable is the prevention of free gas spaces or open voids in the insulation. One of the chief causes of formation of such voids is the thermal shrinkage of the oil during decreases in cable loading. With the complete solution of the thermal transient available, a thorough investigation can be made of the possibility of this happening from an oil pressure standpoint for any assumed load conditions.

The pressure drop across the wall of insulation depends on the resistance of the paper tapes to radial oil flow. The insulation of commercial cables is often arranged in zones, the density of the tapes being different for each zone. It is necessary to know the dimensions of these zones, and their respective coefficients of friction to radial oil flow. Actual values for the latter have been found to range from 50 to 500 near the sheath, and 400 to 1,000 near the conductor, the units being (lb per sq in.) per (in. cube) per (cu in. of oil per hr) for oil having a viscosity of 50 centipoises.

The process of solution for the radial pressure drop due to a rectangular load change is sufficiently illustrated in Fig. 3. In part 2, $a_3$ is obtained from eq 4 by replacing $r$ by $x$ if oil feed is from a hollow core only; for feed from sheath channels only, $x$ replaces $R$. For general load variation the generalized form of the rectangular solution should be used. The calculated pressures, part 4, must of course be altered by an additive constant for hydrostatic pressure so as to make the pressure at the inside (or outside) radius of the insulation equal to the pressure in the oil core (or sheath) at the moment under consideration. If the final resultant pressure is anywhere less than the partial pressure of solution of gases absorbed in the oil, then presumably voids will form.

Following the procedure outlined, a graphical solution of the radial pressure drop was computed for one of the oil filled cables installed in Chicago. Under the most severe conditions of dropping load in the winter, the radial pressure drop was only a fraction of a pound per square inch, or much less than the minimum permissible oil pressure in the core. In the present design of oil filled cables, the radial oil pressure drop is insignificant because of the small viscosity of the oil. However, in solid cables with thick compound this is not so, and the type of analysis given above is useful in determining internal pressures and vacuums developed during load variations.

## VERIFICATION BY FIELD AND LABORATORY TESTS

The theoretical methods have been found to give results in close agreement with actual measurements in every case which has been checked. For example, the curve of Fig. 4 was selected at random from a series of tests made at the University of Wisconsin. The calculated points are shown by the circles. The agreement between calculated and test

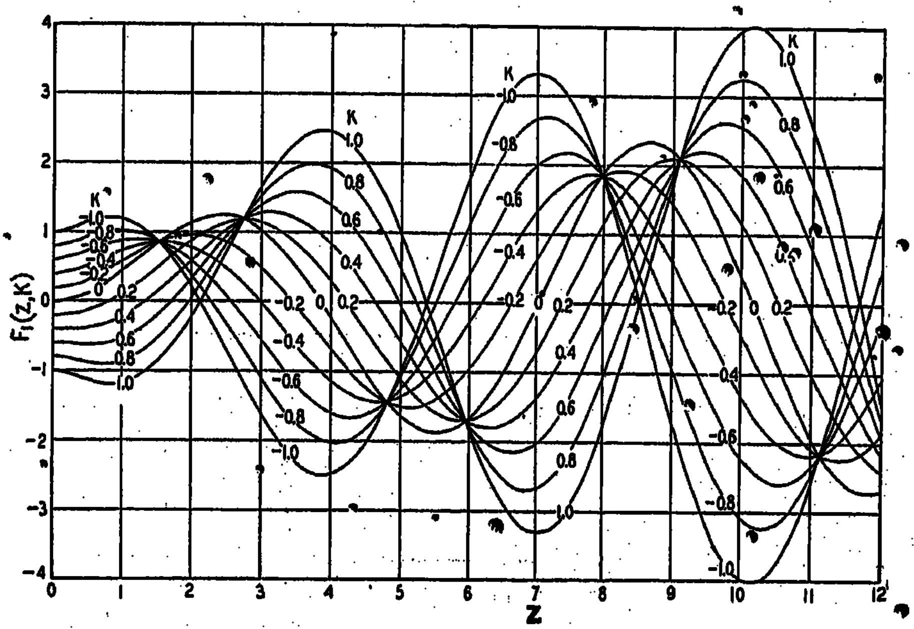
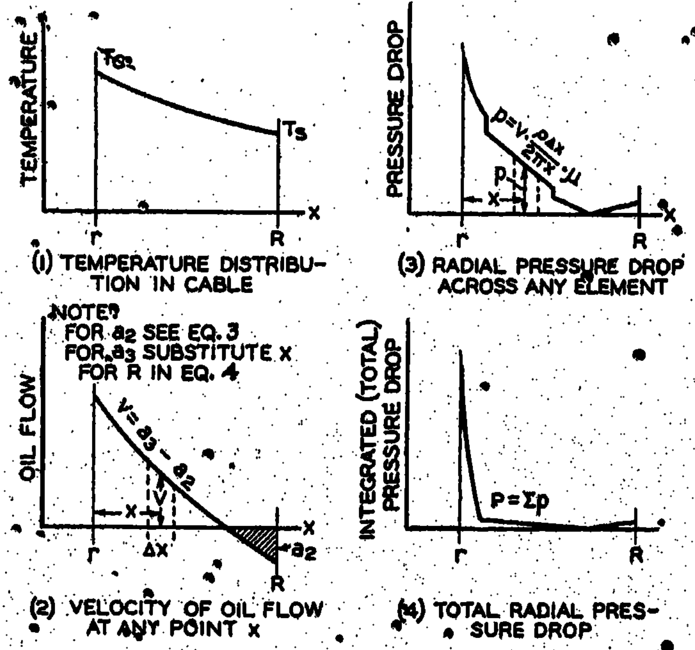


Chart 4. Functions $F_1$



(1) TEMPERATURE DISTRIBUTION IN CABLE

(3) RADIAL PRESSURE DROP ACROSS ANY ELEMENT

(2) VELOCITY OF OIL FLOW AT ANY POINT x

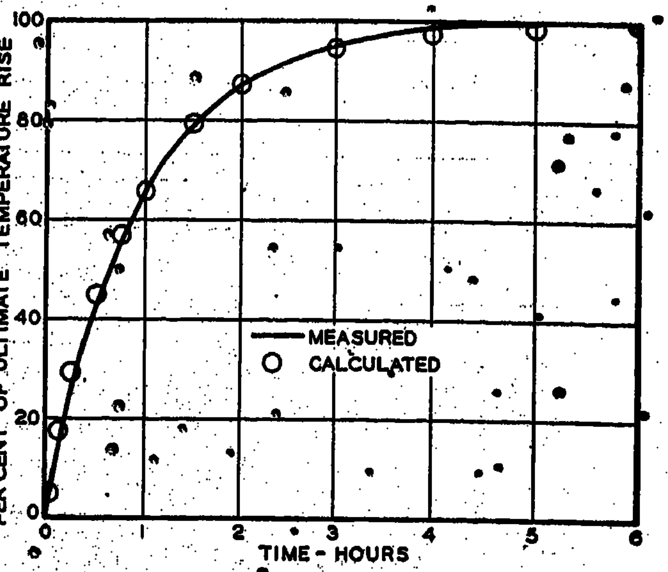
(4) TOTAL RADIAL PRESSURE DROP

**Fig. 3. (Left) Solution for radial oil pressure drop in cable insulation**

Illustration is for cable having oil feed from hollow core only

**Fig. 4. (Right) Copper temperature transient due to abrupt change in copper losses**

Single-conductor 500,000-cm cable having 26/64 in. ordinary insulation and 7/64 in. lead sheath



values is almost perfect except for the latter part of the transient. The disagreement is due to the fact that in the test, the heating current was kept constant. This resulted in a continuous slight increase in the conductor losses, due to the rising conductor temperature. It was not thought worth while to include a correction for this residual effect in the calculations, which are based on the assumption that the conductor loss remains constant after the transient is initiated (see Fig. 1). The last few calculated points, therefore, fall slightly below the test points.

Field tests in Chicago on 2 132-kv oil filled lines provided an opportunity of testing the theory from every angle. In the field tests, a heavy load (200,000 kva in one case) was suddenly thrown on the line, maintained as nearly constant as practicable for several hours, and then suddenly switched off. Records were obtained of conductor current, volumes of oil in feeding reservoirs, and oil pressures at various locations along the line.

The tests were entirely reconstructed by theory, the only known factors being the constants of the cable, the loads employed, and the duct temperature. The results are shown in Tables II and III. Table II provides a check of the slope of the temperature transient curve, as well as of oil flows, since the oil flow depends upon the rate of change of temperature. The agreement is good, and most of the error probably lies in the measured values, since the type of oil reservoirs used made it impossible to obtain precise oil volume measurements. Table III provides a check of the actual cable temperatures as well as of oil pressures, since the pressures depend on the oil viscosity and therefore on the cable temperature. The close agreement between measurement and calculation in Table III is a further indication that the calculated values of Table II are more precise than the measured values. An unavoidable error was, of course, introduced in all the calculations by the necessity of assuming that the duct temperature was the same throughout the length of the cable. Actually the duct temperature probably varied considerably from manhole to manhole.

**Table II—Comparison of Measured and Calculated Maximum Rates of Oil Flow During Heat Runs on Northwest-Devon 132-Kv Cables**

| Line 7,401 | | | |
|---|---|---|---|
| Load-Amp | | Max Rate of Flow Gal per Hr | |
| Initial | Final | Measured* | Calculated |
| 160 | 420 | $6.6 \times 10^{-4}$ | $7.2 \times 10^{-4}$ |
| 400 | 150 | $7.3 \times 10^{-4}$ | $7.0 \times 10^{-4}$ |

| Line 7,406 | | | |
|---|---|---|---|
| Load-Amp | | Max Rate of Flow Gal per Hr | |
| Initial | Final | Measured** | Calculated |
| First Test: | | | |
| 0 | 950 | $12.7 \times 10^{-4}$ | $13.1 \times 10^{-4}$ |
| 830 | 0 | $11.3 \times 10^{-4}$ | $11.2 \times 10^{-4}$ |
| Second Test: | | | |
| 0 | 800 | $7.1 \times 10^{-4}$ | $9.3 \times 10^{-4}$ |
| 800 | 0 | $8.2 \times 10^{-4}$ | $10.4 \times 10^{-4}$ |

* Average value for 6 sections
** Average value for 3 to 6 sections

## CONCLUSIONS

1. A simple solution has been obtained for cable transients due to a rectangular load change. The theory has been verified by measurements on actual cables of the ordinary and oil filled types.

2. Mathematical and graphical aids have been developed which greatly reduce the time and labor required for numerical work. Solution and verification of a complete problem formerly required about a week. With the aid of the new methods, the same results can now be obtained in one day.

3. The transients due to load variations of any complexity whatever have been solved by using the well known superposition theorem. Any desired degree of accuracy can be obtained.

4. The duct temperature transient is of importance in problems of variable loading, but has not been adequately investigated. Further work should be done along this line.

5. Some of the constants needed for use in thermal and oil flow problems of cable insulation are relatively new. Many of the values now in use for these constants are based on only a few scattered observations. Further laboratory and field data should be obtained.

## LIST OF SYMBOLS

$t$ = time in second
$r$ = inside radius of insulation
$R$ = outside radius of insulation
$x$ = radius of cylindrical element considered
$Q_1$ = total thermal capacity of copper conductor and free oil in strands and core (if any) per unit length, Joules/deg C
$Q_2$ = total thermal capacity of sheath, armor, shielding tapes, and free oil in channel or sheath flutes (if any) per unit length
$q$ = specific thermal capacity of insulation, per unit volume
$p$ = specific thermal resistance of insulation, per unit volume
$w$ = dielectric loss per unit volume at unit voltage gradient

**Table III—Comparison of Measured and Calculated Oil Pressures in Cable Cores During Heat Runs on Northwest-Devon 132-Kv Cables**

| Sec. No. | Oil Pressure-Lb per Sq In. | | | |
|---|---|---|---|---|
| | Maximum | | Minimum | |
| | Meas | Calc | Meas | Calc |
| | Line 7,401 | | | |
| 1 | 28.5 | 29.4 | 15.5 | 14.4 |
| 2 | 26.0 | 26.0 | 12.0 | 11.4 |
| 3 | 25.0 | 24.4 | 13.0 | 12.6 |
| 4 | 26.0 | 24.1 | 15.0 | 14.0 |
| 5 | 26.0* | 25.0 | 13.0 | 12.5 |
| 6 | 38.0* | 37.9 | 16.0 | 16.8 |
| | Line 7,406, Second Test | | | |
| | 20.5 | 19.2 | 8.0 | 7.3 |
| | 20.0 | 19.5 | 8.0 | 6.2 |
| | 10.0** | 8.6 | 2.0 | 2.1 |

* Estimated. Boosters were reconnected at peak pressure.
** Balanced pressure section. Reservoirs disconnected at one end.

$E$ = thermal resistance, sheath to duct, per unit length
$G$ = thermal resistance, copper to sheath, per unit length
$T$ = temperature deg C at point and time considered
$T_o$ = duct temperature
$W$ = watts heat flow across cylindrical element at $x$
$W_c$ = watts copper loss
$W_i$ = watts dielectric loss per unit length of cable
$W_s$ = watts sheath loss
$C$ = total volume copper conductor and free oil per unit length
$V$ = total volume inside of lead sheath or inside of shielding tape, if any
$c$ = effective volumetric thermal coefficient of expansion of copper core and free oil combined, per deg C
$\epsilon$ = effective volumetric thermal coefficient of expansion of insulation, oil and paper combined, per deg C
$v$ = effective volumetric thermal coefficient of expansion of lead sheath, corrected for free oil in channel or sheath flutes, if any
$a_1$ = rate of oil flow contributed by conductor and core, cu cm per sec per unit length

$a_2$ = rate of oil flow contributed by lead sheath shrinkage or expansion, corrected for oil in flutes or channels, if any
$a_3$ = rate of oil flow contributed by insulation
$a$ = total resultant rate of oil flow, per unit length
$\rho$ = resistivity of insulation to radial flow of oil of standard viscosity
$\mu$ = correction applied to $\rho$ to take account of actual viscosity of oil
$\Delta$ = finite increment of quantity considered

Thermal "constants" are assumed independent of temperature

Subscripts $c$, $i$, and $s$ refer to conductor, insulation, and sheath, respectively

Superscript ($'$) indicates conditions before transient

Superscript ($''$) indicates conditions during and after transient

All logarithms are to base e.

# A Rotary Voltmeter

**A new electrostatic voltmeter for measuring either a-c or d-c potentials has been developed; it has a range limited only by its insulation, possesses high accuracy, and draws no current. This article describes the new meter and some of its uses.**

By
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DESCRIPTIONS of high voltage voltmeters by the dozen may be found sprinkled through the literature of engineering and physics, and in the face of this wealth of invention the proponent of yet a new one feels required to justify his entrance into the well filled field. The defense offered in this case lies precisely in this abundant bibliography and in the thought that these continued and varied efforts strongly suggest a problem still unsolved. Instruments excellent in some respects have generally purchased such excellence by sacrifices in other respects. Highly accurate electrostatic voltmeters acting upon attraction or repulsion principles have been constructed, but unfortunately they are non-portable, non-linear, and dependent upon other meters for their calibrations. Spark gaps are rugged, portable, and simple to construct, but their limitations in other respects are too well known for comment. Wire-wound high resistances of good design, used in conjunction with a galvanometer or potentiometer, are accurate and highly satisfactory to those who can afford them, at least in constant potential applications. In some cases, however, the load which they impose upon the high potential source is undesirable.

The instrument to be described here operates according to principles which are thought to be new in high potential measurements, and accordingly it possesses a set of characteristics not duplicated in other existing meters. Fortunately, practically all of the well-known defects have been avoided, and no new ones have appeared during a testing period of more than a year in routine service, unless the noise produced by the running of a small motor be accounted a defect.

Briefly this is a rugged and portable a-c or d-c voltmeter of unlimited range, high accuracy, short period and linear scale characteristics. It draws no current, has no detectible temperature errors, and is not unreasonably difficult or expensive to construct. The indicating instrument is at earth potential and may be located remote from the rest of the meter. The calibration of this meter inheres in its construction and may be established without recourse to any high potential manipulations whatever.

Central unit of the meter is a contrivance which may be called an electrostatic generator. It has several points of analogy with a simple 2-pole, separately excited electromagnetic d-c generator. In the electrostatic generator a simple armature rotates in the electrostatic field existing between 2 pole pieces whose difference of potential is to be measured. The armature, driven at constant speed by a synchronous motor, generates a direct current which is directly proportional to the potential difference applied to the pole pieces. This generated current is conducted to a suitably calibrated galvanometer or microammeter, from which the value of the applied potential may be read directly. The whole assembly is termed a rotary voltmeter.

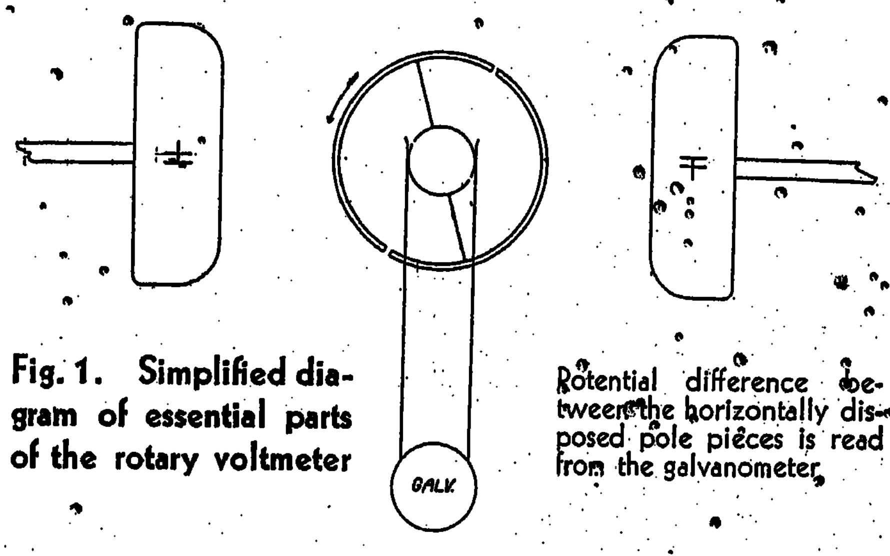

**Fig. 1. Simplified diagram of essential parts of the rotary voltmeter**

Potential difference between the horizontally disposed pole pieces is read from the galvanometer

Essentials of the meter are shown in Fig. 1. The so-called armature is a piece of metal tubing which has been sawed longitudinally into 2 equal semicylinders. These are connected electrically only by the path leading through the commutator and galvanometer. When the meter is in operation, the galvanometer receives a pulsating direct current the average value of which, as shown by simple theory and many experiments, is given by the formula $I = 2CVn$, in which $V$ is the applied potential

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Prepared especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

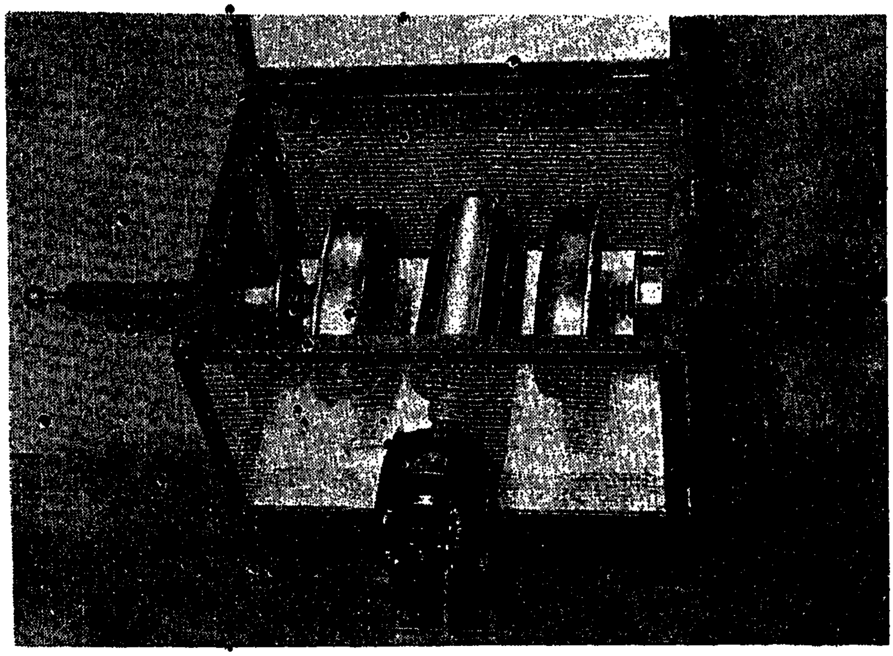


Fig. 2. Rotary voltmeter for measuring potentials from 1 volt to 110 kv; complete except for galvanometer

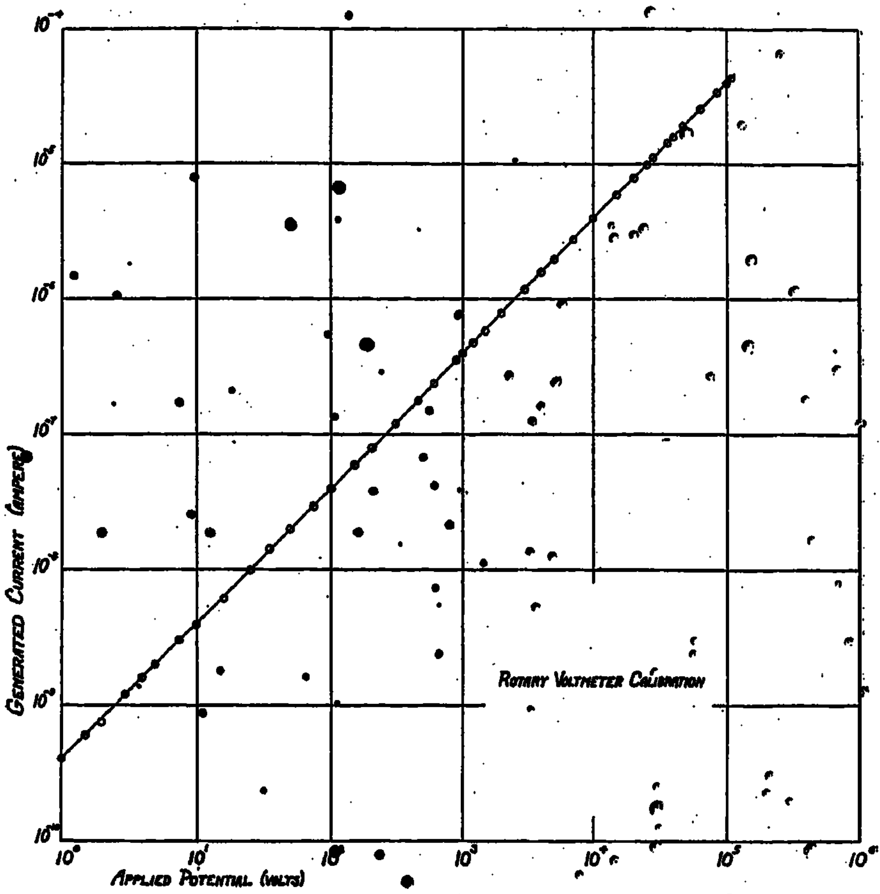


Fig. 3. Experimental calibration curve for the instrument shown in Fig. 2. The curve is straight and agrees with the theoretical equation $I = 2CVn$

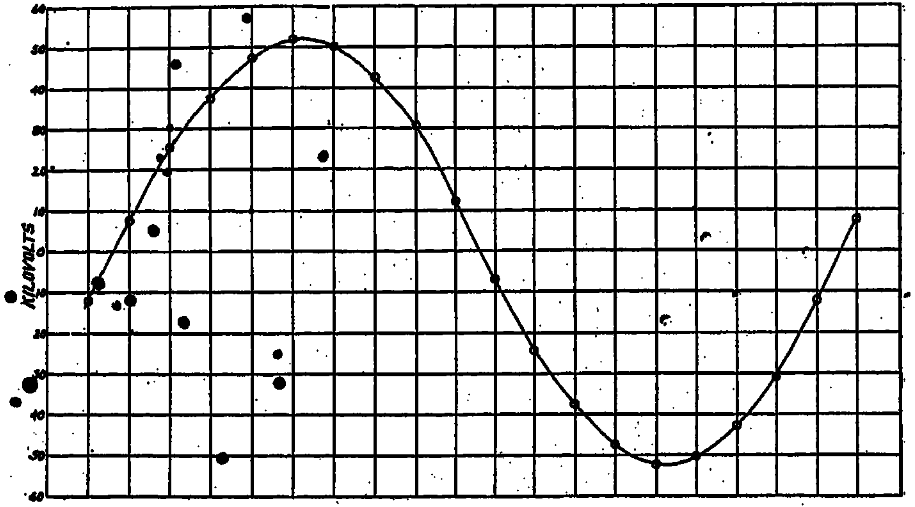


Fig. 4. Potential wave form across the secondary terminals of a high voltage transformer, as determined with the rotary voltmeter

(here supposed constant) $n$ the speed of rotation of the armature in revolutions per second, and $C$ the capacitance of a system comprised of the armature and one pole piece. This equation has been checked exhaustively on 3 different generators, in many cases with all relevant quantities independently measured; it holds rigorously over a wide range of voltage.

The generator shown in Fig. 2 was built for measuring potentials up to 110 kv. The upper limit is set only by the limitations of the insulators and the width of the gaps between the pole pieces and the rotor. The wide range of potentials measurable with this meter and the proportionality existing between potential and generated current over the entire range are displayed by the graph in Fig. 3. The circled points represent corresponding values of independently measured applied potentials and generated currents. Currents such as those designated at the lower end of the graph require a rather sensitive galvanometer for their measurement, but up in the practically useful part of the range a portable microammeter of the pointer type or a switchboard microammeter is perfectly adapted and most convenient.

Calibration constant of a voltmeter of this type may be determined either by applying a known potential of a few hundred volts and measuring the resulting current, or by measuring the capacitance $C$ and taking account of the known speed of rotation. Both methods have been found to be practical and easy and the resulting calibrations to be correct to within a small fraction of one per cent. It is found in most cases that the accuracy of the rotary voltmeter is simply the accuracy of the indicating instrument itself. Calibration methods have been more fully described in another article published in *Review of Scientific Instruments*, v. 3, 1932, p. 430–8.

As mentioned previously, the rotary voltmeter is useful for measuring alternating as well as direct potentials. Close analysis of the generating process shows that the only potential difference of significance in the equation $I = 2CVn$ is the potential difference existing when the semi-cylinders of the rotor are turned directly toward the pole pieces, that is, at the instant of commutation. In other words, the generated current is proportional to the *instantaneous* value of the applied potential at a certain instant during the rotation. If the rotor is driven by a 4-pole synchronous motor connected to the same power system as that which furnishes the potential to be measured, this instantaneous value recurs identically twice in each revolution, that is, at each commutation point. The voltmeter then measures this instantaneous potential, regardless of the potentials that may obtain during other parts of the cycle.

By advancing or retarding the rotor in its synchronous rotation various potentials along the applied voltage wave may be determined in turn and the entire wave form expeditiously plotted in a point-to-point manner. This control of the rotor phase has been accomplished in two ways: by bodily rotating the motor a portion of a revolution about its own axis; and by operating the motor on current from a phase shifting transformer. The latter method, which has the advantages of greater simplicity and convenience, was employed in determining the output wave form (see Fig. 4) of a high voltage transformer.

High potential wave forms for various conditions of rectification, filtration, and load have been determined by this method. When it is desired to measure only the peak value of an alternating potential the rotor phase may be set for the maximum generated current and left in that adjustment. These voltmeters so far have been used only in a few experimental X-ray laboratories; but their dependable and inconspicuous performance in these cases suggests that they will be found useful in a variety of other applications.

# Pneumatic Tired Diesel Electric Rail Car

A DIESEL electric rail car having a body of stainless hi-tensile steel construction and running on pneumatic rubber tires has recently been delivered to the Reading Company. Much fundamental development work in the building of this 47-passenger car was done by the E. G. Budd Manufacturing Company, involving the forming and handling of thin sheets of steel, and requiring considerable research into methods of welding. As the result of this work the weight of a self-propelled car of a given seating capacity has been reduced to 33 per cent of the weight of the accepted passenger coach having no power as used on Class I roads.

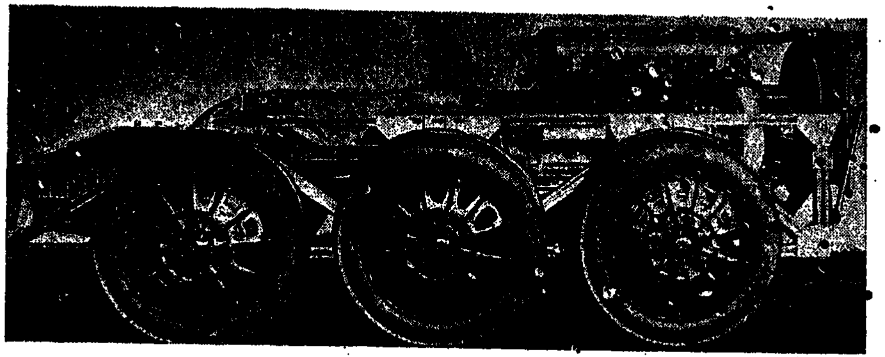
The front or power truck is equipped with a 125-hp Cummings diesel engine directly connected to a Westinghouse 250-volt generator of special light weight construction. In the power truck also are mounted the batteries and control. The rear or traction truck is a single high speed Westinghouse motor mounted under the bolster. The double extended shaft drives the front and rear axles of the traction truck through a Timken differential worm gear having a ratio of 9.1 to 1.

The trucks, of unusual design, are of light weight construction. The power truck has a "shot-welded" stainless steel frame weighing 281 lb, while with the engine, generator, batteries, axles, wheels, etc., the total weight is 6,990 lb. In the traction truck the "shot-welded" stainless steel frame weighs but 230 lb, whereas the motor, axles, wheels, etc., make the total weight 4,315 lb.

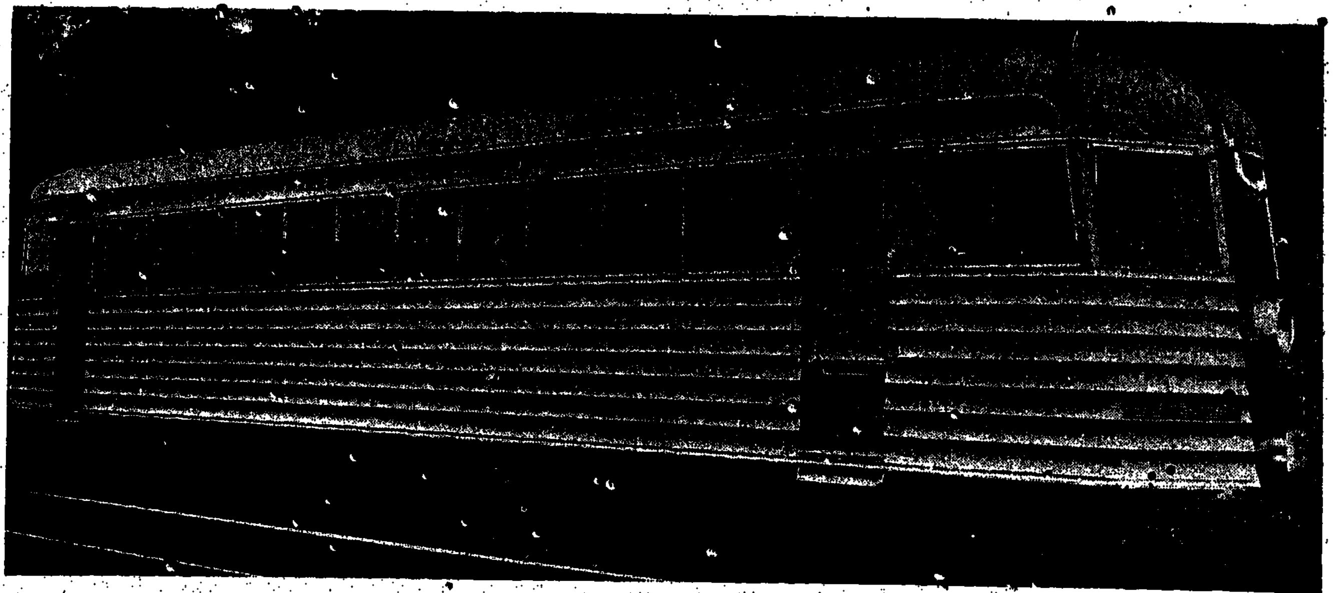
The interior of the car is of extremely simple design, the vestibule being free of any obstruction from the engine. Lighting receptacles are recessed on either side of the exhaust ventilating duct which runs along the center of the car, resulting in a very pleasing and efficient scheme of indirect lighting.

The windows are permanently closed, keeping out the dirt and much of the noise. An ingenious ventilating system takes in air on either side of the car at the step wall and by a motor operated fan distributes it along either side of the car. In winter the air is drawn through a radiator heated by water from the engine. The air is then distributed by conduits evenly through the car. A radical design of reversible seat has been used, the double seat with rubberized hair and leather covering weighing but 50 lb.

Stainless steel marker lights are built neatly into each of the 4 corners of the car. Automatic air engines operate the side doors, trap doors, and folding step, as a unit. The controls of the car are simply arranged for operation from either end of the car.



The front truck of the diesel electric car. This truck carries a 125-hp diesel engine and direct connected 250-volt generator. Batteries and control also are mounted on this truck. The rear truck, not shown, carries the traction motor



Pneumatic tired diesel electric rail car of stainless hi-tensile steel construction. No paint is used on the outside of the car, the stainless steel permitting a permanent luster finish. The car is 51-ft in length, weighs approximately 22,000 lb, and has a speed of from 50 to 55 mph. The tires are 33 x 4½ in., and carry a pressure of 95 lb

Oil pressure, water temperature, and engine speed are all relayed by light circuits.

The rapid acceleration of the car, the riding qualities of the pneumatic tired wheels and the exclusion of noise and dirt combine to give an extremely pleasant reaction to the passenger. When properly applied economies may be secured by this type of high speed light weight self-propelled car which should make it attractive to the railroad operator.

# Usury on Labor

**Too great success in cornering our mediums of production is considered responsible by many for our present industrial instability; the result is usury on labor. This is the fifteenth article in the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"**

By
**ROBERTSON MATTHEWS**
Research and Development Engineer, Bolton, Canada

MACHINES now idle that were running 24 hr per day in 1928 and '29, create a situation demanding correction. Not many years ago we had a moneyed class able to aid liberally in the support of education and general culture, with machinery operated 10 hr per day; with better machines running 24 hr our moneyed class has not been able to keep the business ship on an even keel nor to provide those conditions which history shows are usually a preventive of radical measures and social unrest. After 2 or 3 yr with machines manned by shock troops 24 hr per day, we are having more than 2 yr with those machines largely idle. The cause is declared an obscure mystery. What we learn from this mess is going to depend upon what we do about it.

Our sires thrived on the 10-hr day. We have more machines, better machines, a more elaborate organization; and in many lines we are overtooled.
commodity appears to be attractive
many rush to make it. Where
ble, 24-hr operation is taken as
system capital thus leads
ng like an engine without a governor; but systems, like engines, can destroy themselves if ungoverned.

Now we know (after being forced to learn) that long hours of labor per shift are not best for economic production and social progress. Is it not, therefore, possible that 24-hr operation of machines, though admittedly representing 100 per cent load factor for money invested, has some wide influence which is highly pernicious to business and social harmony? May not more cooperative planning, even internationally, be essential in order to govern the capitalistic engine as now massively and highly developed?

Success in business has too long been significant of predatory characteristics; but has any national organization based upon war and predatory behavior long survived? Why in peace time the pressure of 24-hr operation of machinery? Under what circumstances is it socially permissible? What relation should hours of machine operation per day bear to hours of labor for each shift?

## CORNERING HAS BEEN GOING ON FOR AGES

For ages there have been attempts by some members of a community to corner the prevailing medium of exchange, and to release it for use by other citizens only on prepayment of excessively high interest. This is usury on money, and there are state laws respecting it. Respecting mediums of *production* we still are without proper correctives against cornering. Too great success in cornering our mediums of production, among which labor takes first place, is considered responsible by many for our present industrial instability. Before society can enjoy the activities of labor and benefits from engineering progress, a few persons who are in control demand an over-large portion of the returns for themselves. In short, the result is *usury on labor*.

Social welfare and stability demand, therefore, that all workers shall share in the greater returns from an improved load factor of a manufacturing plant. Should the market warrant 12-hr operation of machinery, then let there be, say, 2 shifts of 6 hr each; if 20-hr operation, 4 shifts of 5-hr each; if 24-hr operation, 6 shifts of 4-hr each, the pay to remain approximately the same *per shift*.

With such pay, employes could better meet the fluctuations in employment likely to occur for some years, until we arrive at a better social-industrial organization. This procedure would offer to all concerned in manufacture an incentive for improving the product and its market. The unequal hours in different industries might draw the better grade of workers to places where the hours were most favorable. This would be placing benefits among those workers most likely to benefit society, and whose betterment would provide opportunity for their higher self-development and culture with more inspiration for their children—social stabilizing conditions such as are becoming eliminated in the present militarized industry with the larger benefits and privileges going to an extreme few at the top.

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**Editor's Note: Pursuant to the invitation of the Engineering Foundation, the editors will be happy to receive comments, criticisms, or discussions pertaining to this or other articles published in this series.**

# Telephone Cables in Large Buildings

**Design of telephone facilities for large buildings requires the careful consideration of a large number of factors to insure that the telephone plant shall be used with the maximum degree of efficiency. The factors which must be considered are outlined in this article, which is a portion of the authors' complete paper on the general subject of cables for telephone distribution.**

By
M. C. ROSE
ASSOCIATE A.I.E.E.

H. A. RUSSELL
NON-MEMBER

Both of the Chesapeake and Potomac Tel. Co., Baltimore, Md.

PLANNING of telephone facilities for large buildings is a problem which rivals in importance the planning of the telephone distribution system between the central office and the customer's premises. Telephone cables used for distribution within a building are termed "house" cables. Close cooperation is necessary between the telephone engineer and the owner, architect, or contractor in order that the house cable system may be designed to conform to the building layout, and in order that the building plans may include the provision, by the owner, of the necessary shafts, conduit, cabinets, and other housings for that house cable system.

## Building Cable Design

In considering the problem of furnishing telephone service to large buildings, it is quite impracticable and uneconomical to place a pair of wires through the building each time a telephone is required. Buildings of these types are generally given service by means of house cable which is placed in the building during its construction, and provides facilities which will permit convenient and efficient connections of telephones at any location within the building. The house cable system is usually designed to meet the maximum requirements of the building with sufficient flexibility to care for any changes in the relocation of the telephones or for any rearrangements to the building.

These systems usually consist of one or more riser cables starting directly from an entrance cable or from a main cross-connecting terminal or frame in the basement, and extending up through shafts or conduits of the building. Branch cables on each floor are terminated at suitable distribution points by means of floor terminals, where connections are made to the subscriber's telephones by wires.

The general arrangement of the house cable system is almost identical to the general outside plant arrangement in a central office area in that the riser cables may be likened to the main underground cable, the floor branch cables to the subsidiary distribution cables and the floors themselves to individual blocks or areas along a feeder route.

## Class of Buildings

For the purposes of house cable design, large buildings are put into one of 2 classifications, depending upon the expected permanency of stations, both as to number and location, as follows:

1. *Office and loft buildings* in which telephones do not remain fixed either in number or location for any extended period but vary with the requirements of the individual, who will use more or less telephone service according to respective activities.
2. *Hotel and apartment houses* in which the number and location of telephones are fairly definitely fixed by the number and arrangement of rooms or apartments in the building and the telephone service required by successive occupants is approximately the same.

## Planning for Requirements

Unless suitable housing facilities are provided in advance for accommodating cables and wires and for passing them through the walls and floors, either exposed telephone installations will result in unsightly conditions, subject to possible damage with subsequent undesirable effects on service, or extensive costly alterations may be required after completion of the building to conceal effectively all cables and wires. These systems of housing facilities include cable and wireshafts, conduit boxes, molding raceways, underfloor ducts, etc., and are designed to conform to the maximum requirements in common with the water, gas, electric light, and power conduits as an integral part of the building. The vertical accommodations (for the riser cables) start from the basement and rise to the top floor connecting at the various floors with horizontal housing facilities, and junctions between cable conduits are effected by means of splicing closets or splicing and terminal boxes whereby complete passage is afforded for cable and wire from the basement to the location of the station.

Consideration is given to the intended present and future use of a building, the character of its location and average rental value in order to design the cable plant to meet the conditions. Experience has shown that maximum circuit requirements have a definite relation to rentable or productive floor area and this relation is the basis for both house cable and housing system design. Pair density factors expressing the relation between rentable or usable floor area and cable pairs provided have been developed for certain cities by an analysis of the use being made of house cable in existing buildings. From these data broad averages have been derived in the form of ranges of

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Full text of a portion of "Use of Cables for Telephone Distribution Purposes" (No. 32-121) presented at the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., Oct. 10-13, 1932.

the number of riser cable pairs per unit of floor area which would provide liberal facilities for the developments realized. These factors are used in determining the amount of facilities to be provided in any particular new problem by applying them to the rentable or usable floor areas.

## CABLE ENTRANCE AND MAIN CROSS-CONNECTING TERMINALS

The cable entrance point is selected with the object of establishing the shortest satisfactory route from the point of connection with the feeder system. Cables are preferably attached to walls or ceilings rather than to partitions which are subject to removal or changes. The number of entrance cable pairs to buildings not served largely by one or several local switchboards is determined in the same manner as the facilities to be provided within the building. The number of entrance cable pairs in a building having private branch exchange service is designed to meet the requirements of one or several switchboards; that is, provide trunk lines, telephone power lines, and facilities for outside extensions, if any, including a surplus of pairs to insure adequacy and also provide central office feeders for stations other than extensions on the switchboard. In some cases the building entrance cable includes facilities for extensions to the adjacent block plant.

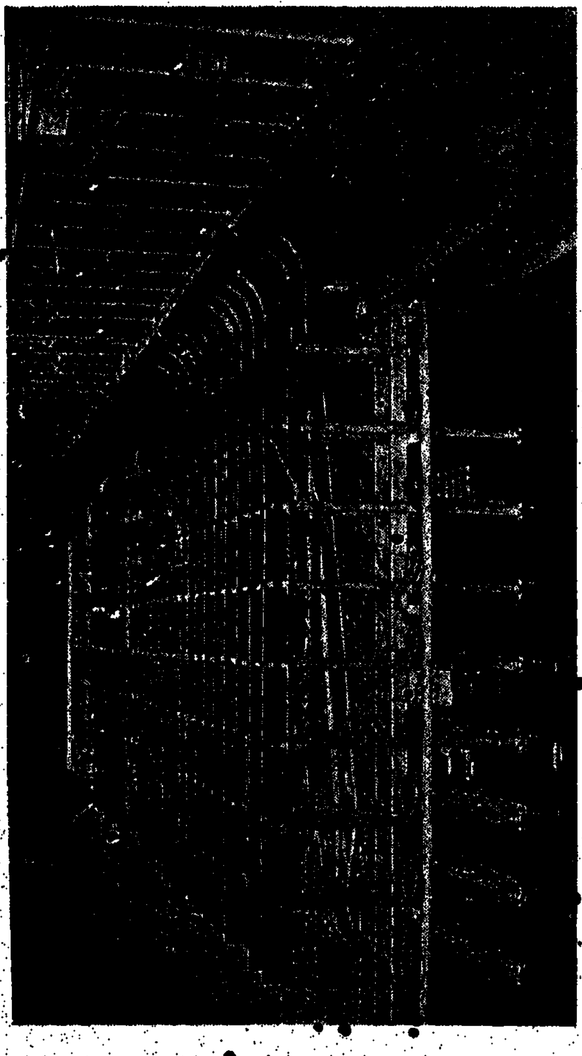
The main cross-connecting terminal or frame, shown in Fig. 1, is usually in the basement at or near the foot of the riser shaft or conduit. The specific location should be determined upon in advance of the building construction in order that the required space may be set aside and the necessary housing accommodations be installed as the building is erected.

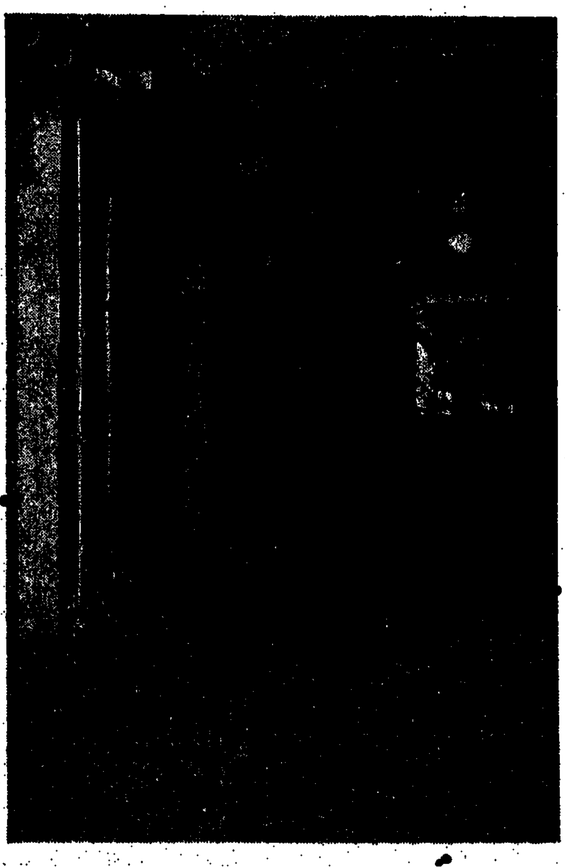
## RISER CABLES AND HOUSINGS

Riser cables, Fig. 2, are designed as nearly as practicable to intersect the floors at the wire centers as determined by study of the typical floor plans. Specific location for the riser cable housing is preferably a permanent corridor partition or in the wall of some public place leading from the corridor and easily accessible without annoyance to the tenants of the building.

In buildings having large distribution areas or in which each floor is made up of several distinct distribution areas, 2 or more riser systems may be desirable, each being used to serve a definite floor area centering about it. In office buildings containing several riser systems, these systems are tied together at certain floors with conduit of sufficient size to house a cable containing enough pairs to permit concentrating the entire floor system on any one riser.

Floor cable and wire housings in combination, afford passage for the telephone circuits from the riser system to the approximate locations of the individual telephones. Cable housings extend more or less directly from the riser to wiring centers on the floor where floor distribution terminals are located and where connection is made with the housings for wire. The floor cable housing system must accommodate a floor distribution cable plant which provides adequate facilities to meet the demand for telephone service on the floor wherever and in whatever quantity it may be. The first step in the design of the system is the determination of the number of cables, including terminals which it will house, their location and size. In small buildings, where the amount of floor distribution is not extensive, the housing system may carry cables and wires together in such raceways as hollow moldings or baseboards. In most





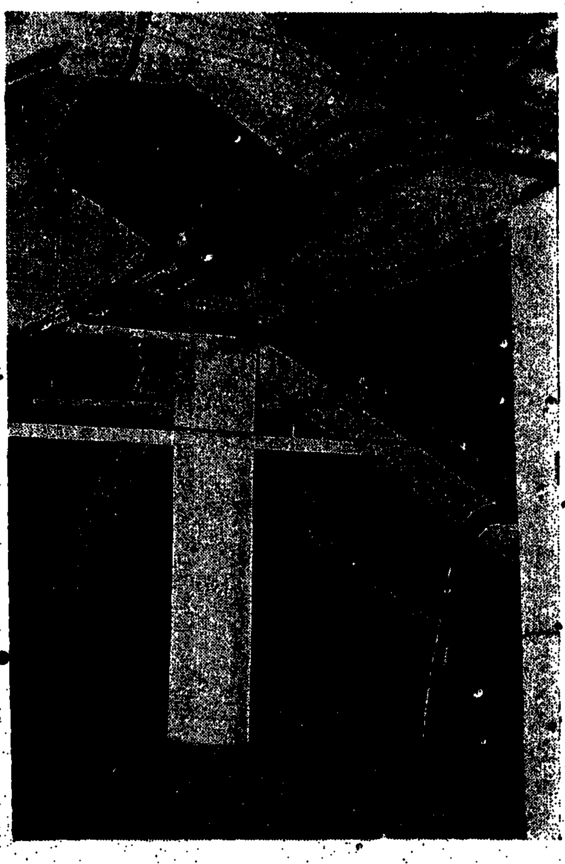


Fig. 1. (Left) Cross connecting frame in building
Fig. 2. (Middle) Section of house cable system in loft of large office building, showing type of riser cable shaft and riser cables
Fig. 3. (Right) Section of house cable run in loft of large building

buildings, however, separate systems for cable and wire are necessary, although it is usually quite practical and economical to place small cables in lieu of wire in housings intended for wire when special distribution requirements make this desirable.

# Centrifugal Air Cleaners Serve Railway Equipment

**Here is given a description of a railway dynamotor-control generator set designed for compactness and fitted with centrifugal air cleaning device, as used on cars for the Lackawanna electrification.**

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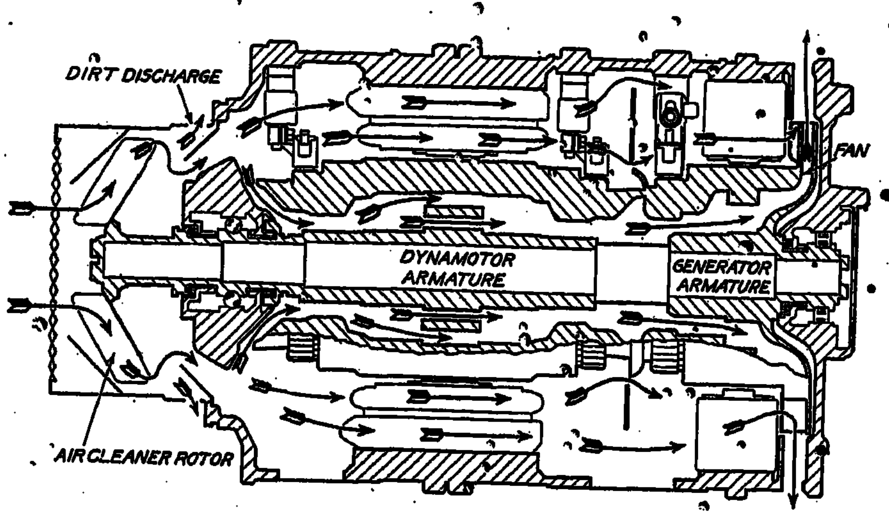
THE DESIGN, and particularly the ventilation of the dynamotor-control generator sets used on the 3,000-volt d-c motor cars in service on Delaware, Lackawanna & Western Railroad, involve several features which are somewhat unusual for electric motor car equipment. This set provides a 1,500-volt source of power for the compressor and 40 volts for lights, control, and storage battery charging.

To avoid encroaching upon available passenger space, the set was mounted feet up under the car body between the trucks where the ventilating air available is likely to be dirty. Because of the long ducts that would have been required, it was considered impractical to obtain an air supply through the settling chambers provided over the vestibules to supply air for the traction motors (J. C. Aydelot, "Motors for 3,000-Volt Multiple Unit Cars," ELECTRICAL ENGINEERING, June 1932, p. 401). The alternative of totally enclosing the set also was discussed, but the machine could be made so much smaller and lighter if well ventilated that the idea was rejected. Since centrifugal air cleaning devices to furnish about the same volume of air already were in use in other classes of service, a test machine was constructed with such a device and tests were made to determine the cleaning efficiency. On test the cleaner performed creditably, removing from the air practically all the denser materials such as iron filings and a large percentage of the lighter materials such as powdered talc. These materials were selected for the test as being comparable to brake shoe dust and fine snow, the two most detrimental materials normally encountered. For approximately 2 years these machines have been in service on 141 motor cars, without any trouble chargeable to foreign matter in the ventilating air.



A self-ventilating duplex railway machine

General design of the entire set is shown in the accompanying sectional view, where it may be seen that the radial blades of the centrifugal cleaner impart a swirling motion to the entering air which causes all particles heavier than the air to be thrown to the outer casing of the cleaner. As the air is drawn toward the machine by the exhaust fan a conical splitter divides air stream; the air near the surface of the casing and carrying most of the dirt being ejected, and the air remaining at the center entering the machine. The clean air then is divided further: one stream passes over the commutator, around the brush holders, through the air gap and the spaces between the field coils, and out through the fan and exhaust openings; the other stream passes beneath the commutator, through the longitudinal ducts in the armature cores, and out through the fan and exhaust ports.

Although the control generator is a low voltage machine and hence not readily rendered inoperative by dirt, a supply of clean air for it, too, is highly desirable in order to reduce both brush and commutator wear by excluding most of the abrasive matter from the cooling air. To enable one cleaner and one fan to serve the set, the motor and the generator are ventilated in series, with the generator in second position principally because it is the smaller machine and because the low voltage permitted more flexibility in design. However, since the volume of air used is so great that the temperature rise of the air in passing through the dynamotor is only about 14 deg C, the increase in generator size due to the prewarming of the air is unimportant and is believed entirely justified by the lower generator maintenance.

Mounting the generator within the dynamotor frame, while done primarily to obtain clean air, presents several other advantages:

1. To reduce the over-all length of the set to a minimum, and thereby permit a short, stiff shaft to be used, the control generator was made abnormally large in diameter and short. As a separate machine of this diameter the weight and space of the generator would not be economical, but as an addition to machine of inherently large diameter, the weight and space requirements actually are less than if a smaller diameter had been used.

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Written especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

2. The problem of obtaining good commutation was simplified by the short length of core which decreases the sparking reactance voltage.

3. The large generator diameter makes possible a large radial air space between the bearing and the end windings permitting the bearing to be recessed under the fan, thus shortening the set.

4. Maintenance cost is less because the control generator need not be removed before disassembling the armature, as probably would have been necessary with an overhung design.

When operating at a 2,700-volt average trolley potential the dynamotor will deliver 4.6 amp from the mid-tap for the operation of the air compressor. Simultaneously from the control generator a maximum continuous output of 4.5 kw at 40 volts is available without exceeding a temperature rise of 85 degrees C by resistance in any winding.

The set is semi-fabricated and weighs 2,630 lb complete with air cleaner. Provision is made for convenient inspection of commutator and brushes through openings in the frame normally covered by flexible strap girdles. To insure against the high voltage of the dynamotor being imposed upon the low voltage circuits of the control generator, should an arc to ground or a flashover of the low voltage dynamotor commutator ever occur, a steel flash barrier separates the two commutators which are adjacent and in the center of the set.

# Locating Faults in Power Cables

Power cable fault locating is at times difficult due to a high initial fault resistance or an increase of resistance during the time locating is in progress. A method using a constant current transformer for reducing high initial resistance and preventing its increase, in connection with a short circuiting switch to generate signals for locating the fault, is discussed in this article. A practical assembly of this type of apparatus for cable fault locating is described and operating directions are included.

By
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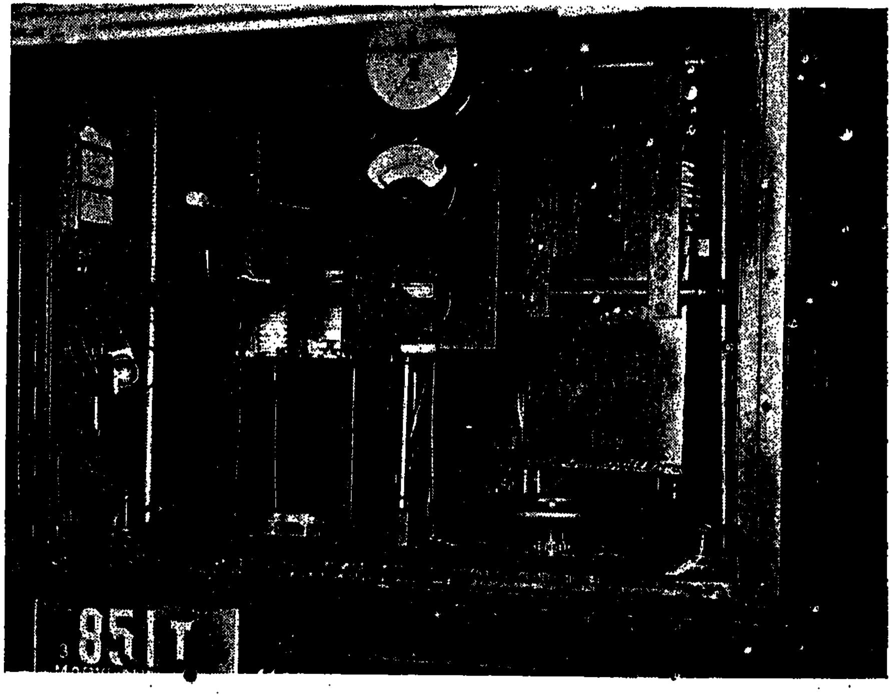

**Fig. 1. Front view of portable cable fault locater mounted on a $1^1/_2$-ton trailer**

A 50-kw 6.6-amp constant current transformer is used to furnish current for carbonizing the fault and signaling. The low voltage rating is 2,300 volts and 25 cycles. The 2 high voltage coils can be connected in series or in parallel; connections are by wingnut and bolt, with a fiber sleeve for insulation over the connection. Coil position is regulated by the hand wheel. Steel spark gaps limit the maximum voltage delivered. The meters on the panel indicate the current and voltage being applied to the cable. A 200-va potential transformer supplies 2 lights and power to drive the rotary shorting switch

THE LOCATION of power cable faults has been facilitated by the design of the portable cable fault locater shown in Figs. 1 and 2, combining a constant current transformer and short circuiting switch with suitable accessory apparatus. Two general methods are in use for locating faults in power cables. One of these involves the use of a bridge to measure the resistance of a conductor to the fault and thus gage its distance from the test station. The other method, and the one on which this portable fault locater is based, requires a signal current to be passed through the conductor to the fault. With this method an exploring coil is held successively at different points along the faulted cable, and an audible indication of the fault location is given by a head-phone connected to the exploring coil.

An investigation started several years ago indicated that the audible signal method was preferable and that some scheme was necessary for reducing the resistance of high resistance faults, and maintaining the fault resistance constant at a low value during the test period. These requirements have been met in the portable fault locater by the use of a constant current transformer for burning and reducing

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Esentially full text of "Locating Power Cable Faults by Means of a Constant Current Transformer With Short Circuiting Switch" presented at a meeting of the A.I.E.E. Baltimore (Md.) Section, May 15, 1931. This paper was awarded the 1931 A.I.E.E. Middle Eastern District prizes, both for best paper and initial paper.

cable faults as well as the generation of a signal current, obtained by means of a rotary switch which intermittently short circuits the secondary of the constant current transformer. A schematic diagram of the cable fault locater is shown in Fig. 3, and the rotary shorting switch in Fig. 4. The great advantage of this method is that the fault is not lost during the process of locating. A not unusual and extremely exasperating experience in fault locating by some other methods is the frequent loss of faults due to healing when low voltage signal current is used, requiring repetition of high voltage tests.

## Fault Reduction

The previously known advantages of a constant current transformer for burning a cable fault are utilized in this equipment. If a fault exists and the voltage applied is high enough to cause an appreciable current flow, the fault will commence to carbonize and the resistance will be reduced. Where the resistance is high, advantage frequently may be taken of the fact that the capacity of the cable in conjunction with the reactance of the transformer may give a condition approaching resonance, thus increasing the applied voltage in excess of the open circuit voltage of the transformer. The different voltages which are possible are illustrated in Fig. 5. A spark gap connected across the cable eliminates the possibility of dangerous voltages in case there is no cable fault to retard the rise.

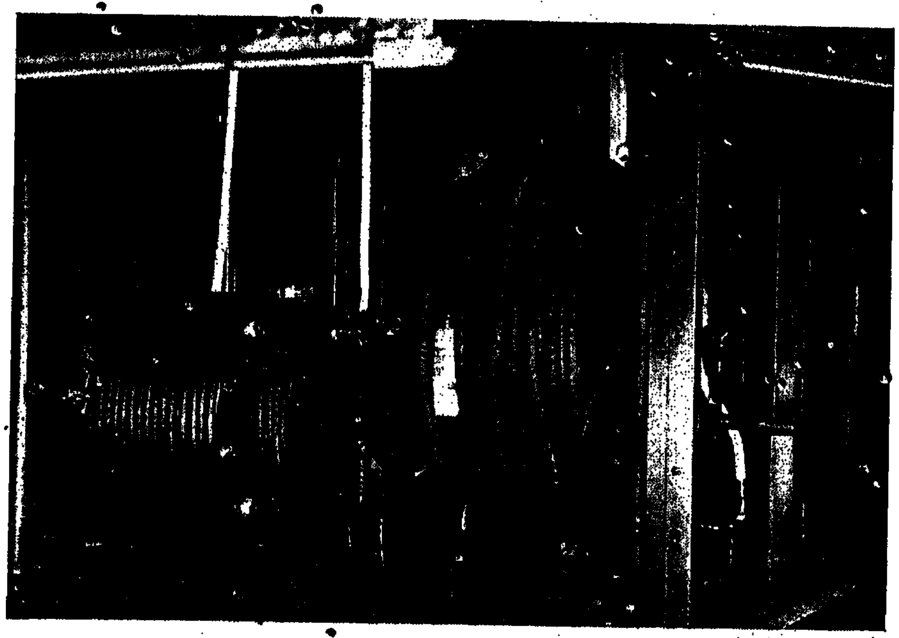

Fig. 2. Rear view of portable cable fault locater

Reels hold lengths of insulated leads for connecting to power supply, ground, and faulty cable. These reels can be locked in position. Removable handles are used when the leads are to be wound up. Suitable clamps are used on the lead ends to facilitate connecting. Connection between the leads on the reels and the wiring on the trailer is made by wingnuts and bolts, with fiber sleeves for insulation

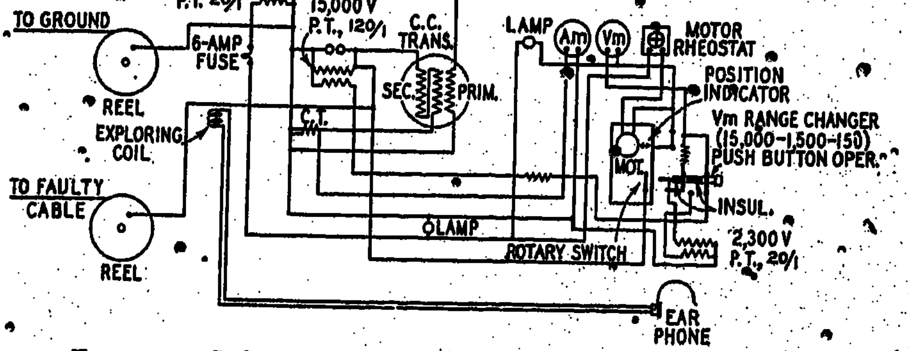

Fig. 3. Schematic diagram of cable fault locater designed primarily for 13,000-volt power cables

The initial voltage available for application to the cable can be varied by changing the amount of connected cable capacity or by changing the inductive reactance of the constant current transformer through a change in coil connection or position. The characteristics of the transformer limit the current to a safe value, and after reducing the resistance of the fault, the current maintains this resistance constant at a low value while the signal current is generated by the rotary shorting switch. The nearly continuous carbonizing effect of the power current is thus obtained simultaneously with the sending of the signal. Tests have proved the method quite satisfactory in regard to signal quality; and in addition a long life of switch contacts is secured due to the absence of high voltage during operation of the shorting switch.

## Operation of Cable Fault Locater

The portable cable fault locater shown in Figs. 1 to 4 is held is readiness in a station where most trouble is expected. Tie cables frequently can be used to connect the locater to faulty cable at other stations. The actual operating procedure for locating a cable fault with this equipment may be outlined as follows:

1. As soon as a fault has occurred, the cable in trouble should be isolated from all apparatus by opening the pothead disconnecting switches. No checking for faulty phase or continuity is necessary.

2. With cutout and oil switch on the locater open, connections are

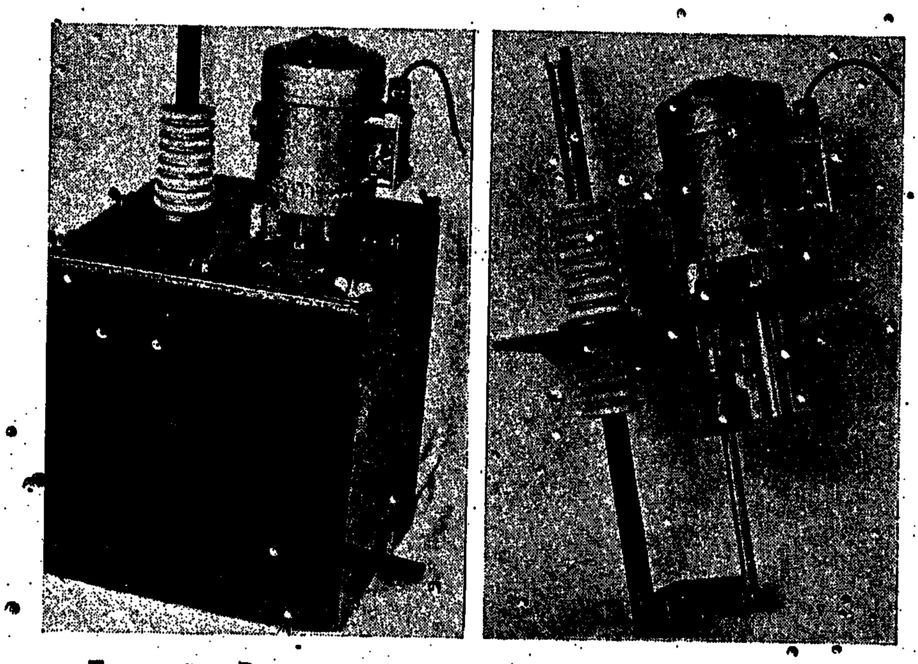

Fig. 4. Rotary switch for intermittently short circuiting the secondary of the constant current transformer in order to utilize the fault reducing current as signal current

An electric drill with a universal motor is used to supply power and reduction gearing. The fixed contact is copper and the moving one is sheet brass or bronze. Oil is used in the tank for insulating and cooling. An indicator needle on the top of the casing and connected by gearing with the moving contact shaft shows the position of the moving contact. A rheostat controls the speed of the motor now made to ground, a 2,300-volt supply (either 25 or 60 cycles) and the 3 conductors of the faulty cable at its pothead disconnecting switches. (If isolated phase system is used, test bus can be used, tying in at the most convenient point.)

3. The 2,300-volt cutout on the locater is now closed. A lamp now lights on the trailer and indicates the supply is alive up to the oil switch. The transformer coils are now set at a maximum distance apart.

4. After first checking that the rotary switch is open, the locater oil switch is closed, and the voltmeter is read. If the voltage wavers, current is being passed through the fault and it is allowed to burn for a while. If the voltage drops rapidly, the carbonizing is satisfactory. If the dropping in voltage takes place slowly it can sometimes be speeded by paralleling the secondary coils or moving the transformer coils closer together. In any event the burning process must continue until the voltage is quite low. For best results it should be 100 volts or lower with the current at 6.6 amp before the signal is put on.

5. In case the voltage does not vary after the cable is made alive, no burning action is taking place. If the voltage shows below the open circuit voltage of the constant current transformer, the connected cable has too great a capacity. To reduce it, reduce the number of phases tied to the locater, tying the extra ones to ground. Now apply voltage again with the locater. If a voltage above open circuit is reached with no evidence of the fault burning, it is probable that the faulty phase is tied to ground. Switch phases and try again.

6. After the fault has properly carbonized, indicated by the voltage being steady and below 100 volts at 6.6 amp, the signal is put on the cable by running the rotary shorting switch. Listening to the phone the speed of the shorting switch is adjusted, by means of the rheostat, to give a ticking sound at about 200 cycles per min.

7. The exploring coil and phone shown in Fig. 6 are carried to cable manholes. Hearing the signal in one hole and getting no signal at the next hole away from the sending station, indicates the fault is between the 2 holes. Care should be taken to place the exploring coil on the cable beyond the cable bonds on the side away from the sending station.

A record of voltages and currents, time to carbonize and locate, should be kept together with notes on the fault. After a little experience with the action of the locater on various type faults, some prediction can be made as to the type fault and whether located in a wet or dry place.

## ACTUAL CABLE FAULTS LOCATED

During a period of $1^1/_2$ years previous to the design of the locater described, 26 power cable faults on the system of the Consolidated Gas Electric Light and Power Company of Baltimore were located successfully by the use of constant current transformer equipment, using 15-kw, 30-kw, or 50-kw transformers. During this period there was only one failure to locate the fault, and this was caused by a personal error and was not due to any defect in the method.

Records have been kept for all faults located (mostly on 13,000-volt cable) and these show that although some stubborn cases required over 2 hr from the time voltage was applied until the fault was located, the great majority required less than one hr. In almost all cases, the fault resistance was reduced sufficiently in a very few minutes so that the test signal could be applied. Voltage readings were taken during each test and these show that on 13,000-volt paper insulated lead sheath cable, some faults may require an initial voltage of 15,000 volts or higher in order to start carbonization of the fault. As the open circuit voltage of a 50-kw 6.6-amp constant current transformer is only about 8,000 volts, the value of the resonance relation for boosting this voltage is quite evident. The maximum voltages measured covered the range from over 15,000 volts down to almost zero, indicating a wide range of fault resistances.

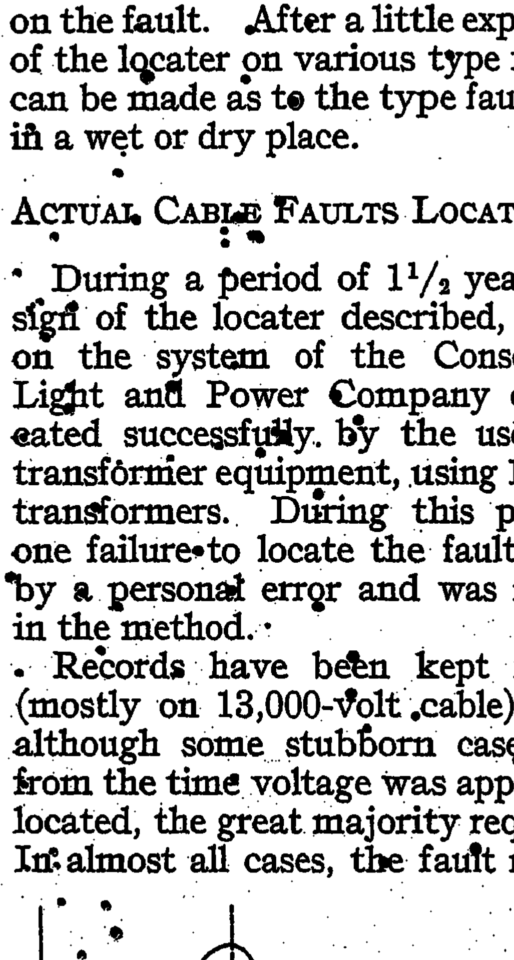

**Fig. 5. General shape of curve of voltage applied by a constant current transformer to a cable without fault**

In quite a number of cases smoke could be seen leaving the duct or could be smelled at the manhole near the fault, thus indicating the close presence of the burning fault. As the current is limited to 6.6 amp there is no damage to nearby cables and yet the current is sufficient to cause a small amount of smoke in most instances, thus assisting in locating the fault.

Two faults in 4,000-volt cables were located and these generally required the application of less voltage. Three faults in 26,000-volt cables were located, 2 of these being in submarine cables. The latter cables, being submerged in water, are particularly difficult to handle, although the appearance of bubbles in the water over the fault may assist in the fault location. A large exploring coil with simple 2-stage amplifier and head-phones carried in a row boat, have been used to locate faults in submarine cable, although some difficulty in distinguishing the signal was encountered over deep water (35 ft) due to the number of foreign sounds picked up. In this case, however, the vicinity of fault was located, and the cable was pulled up by a grappling hook quite close to the actual fault.

Although constant current transformers have been used previously for reducing cable fault resistance, the use of the constant current transformer both for reducing the fault resistance and for sending a signal to locate the fault is believed to be original. That these ideas are practical has been proved by the record of successful operation on a large number of power cable faults.

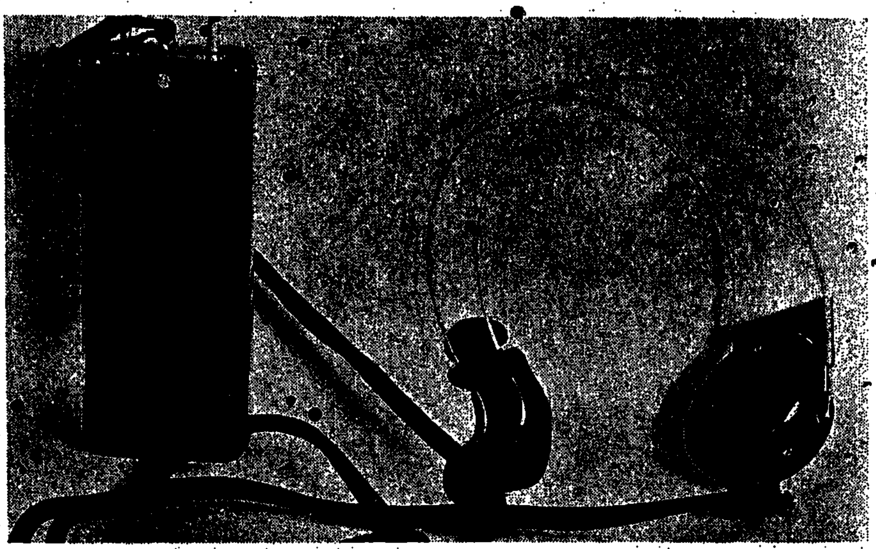

**Fig. 6. Small exploring coil and head-phone normally used to locate the manholes between which the fault is located**

A larger coil and amplifier are used in special cases where it is impossible to put the coil directly on the cable sheath

# News
## Of Institute and Related Activities

# Winter Convention Technical Program Announced

PLANS for the technical program as tentatively arranged for the coming winter convention of the Institute to be held in the Engineering Societies Building, 33 West 39th Street, New York, N. Y., January 23–27, 1933, will convince most electrical engineers that more than the usual number of papers which are of wide interest will be presented. The technical program committee has used great care in the selection of papers which deal with problems most important to the electrical industry at the present time.

Inspection trips, presentation of the Edison Medal, and entertainment features for both men and women are being arranged by the various subcommittees and will be announced in the January 1933 issue of Electrical Engineering. The chairmen of these subcommittees are: convention executive committee, C. R. Jones, Westinghouse Electric & Mfg. Co., New York, N. Y.; dinner-dance committee, C. R. Beardsley, Brooklyn Edison Co., Brooklyn, N. Y.; smoker committee, R. A. McClenahen, United Engineers & Constructors, Inc., Newark, N. J.; inspection trips committee, W. R. Smith, United Engineers & Constructors, Inc., Newark, N. J.; and the ladies' committee, Mrs. E. B. Meyer, South Orange, N. J.

### Technical Sessions

Notwithstanding adverse business conditions the Institute offers its membership an unusual opportunity to hear and take part in the discussion of the most recent advances that have been made in a number of specialized fields of the electrical industry. Thirteen sessions in all have been scheduled during the 5 days of the convention. These sessions have been paralleled so that those which hold interests in common conflict the least with one another and yet related subjects have been grouped close together to permit members who cannot stay for the entire week of the convention to obtain the most that is of interest to them in a shorter interval of time.

Each of several timely sessions have evolved from the close cooperation and united efforts of more than one committee. The communication requirements of railroads will be presented by authors representing 5 well known carriers. This session is under the auspices of the committee on communication, assisted by transportation subcommittee; it should prove to be of particular interest to engineers in both the communication and transportation fields. In addition, there will be another session dealing entirely with transportation problems. One of the papers in this session will present valuable operating data on the Cleveland Union Terminal electrification. One of the electrical machinery sessions, the lightning session, and several papers in the instruments and measurements sessions are closely related. The first treats the problem of insulation coordination, the second deals with lightning and impulse voltage experience with insulators and wood construction, and the third presents the measurement of impulse voltages. The papers which in all probability will be presented in the above sessions, as well as the various other sessions, are listed herewith.

## Tentative Technical Program

### Monday, January 23

**10:00 a.m.—Registration**

**2:00 p.m.—Opening of Convention**

**—(A) Automatic Stations**

Pipe Line Pumping and Automatic Control, John Fies, Texas Power and Light Co.

*The Principle of Condenser Discharge Applied to Central Station Control Problems, F. H. Gulliksen, Westinghouse Electric & Mfg. Co.

*Principles of the Direct-Selection System of Supervisory Control, M. E. Reagan, Westinghouse Electric & Mfg. Co.

*Operating Experience With Automatic and Supervisory Control, J. A. Noertker, The Cincinnati Street Railway Co.

**2:00 p.m.—(B) Electric Welding**

*†Preliminary Report of Research Work Dealing With Nottingham's Equations and the Boiling Points of Anodes in Relation to the Anode Drop in Potential, J. L. Myer, Lehigh University.

*A Natural Arc Welding Generator, G. A. Johnstone, Great Lakes Electric Mfg. Co., Chicago, Ill.

*Transients in Arc Welding Generators, A. R. Miller, Lehigh University.

*High Velocity Vapor Stream in the Vacuum Arc, R. C. Mason, Westinghouse Electric & Mfg. Co.

*Performance and Design of Electric Welders With Controlled Transients, F. Creedy, Lehigh University.

### Tuesday, January 24

**10:00 a.m.—(C) Communication**

Communication Requirements of Railroads, J. L. Niesse, New York Central Railroad Co., and R. C. Thayer, Great Northern Railway Co.

Communication System on the Pennsylvania Railroad, I. C. Forshee, Pennsylvania Railroad.

Railroad Signaling and Train Control, R. B. Amsden and W. M. Vandersluis, Illinois Central Railroad.

Modern Signaling on the Reading Railroad, E. W. Reich and G. I. Wright, Reading Co.

Centralized Traffic Control and Train Control of the Baltimore and Ohio Railroad, J. H. Davis and G. H. Dryden, Baltimore and Ohio Railroad.

**10:00 a.m.—(D) Rotating Electrical Machinery**

Low-Frequency Self-Exciting Commutator Generator, J. I. Hull, General Electric Co.

Some Factors Affecting Temperature Rise in Armatures of Electrical Machines, C. J. Fechheimer, Consulting Engineer.

Parallel Operation of A-C Generators—Action of Governors and Damper Windings, M. Stone, Westinghouse Electric & Mfg. Co.

Synchronous Motor Pulling-Into-Step Phenomena, H. E. Edgerton, Massachusetts Institute of Technology.

Two-Reaction Theory of Synchronous Machines—Part II, R. H. Park, Calco Chemical Co.

**2:00 p.m.—(E) Transportation**

*Application of Air Conditioning to Railroad Passenger Cars, W. C. Goodwin and Charles Kerr, Jr., Westinghouse Electric & Mfg. Co.

*Calculation of Single Phase Series Motor Control Characteristics, H. G. Moore and C. J. Axtell, General Electric Co.

*Operating Data on the Cleveland Union Terminal Electrification, F. H. Craton, General Electric Co.

Power Supply for Main Line Railway Contact Systems, P. A. McGee, Reading Railroad Co., and E. L. Harder, Westinghouse Electric & Mfg. Co.

Simplified Speed Control for Single Phase Locomotives, W. A. Giger, Allis Chalmers Mfg. Co.

### Wednesday, January 25

**10:00 a.m.—(F) Education**

Address—The Professional Development of the Engineer, R. I. Rees, American Telephone & Telegraph Co.

**10:00 a.m.—(G) Insulation Coordination**

*Progress Report on Impulse Testing of Commercial Transformers, F. J. Vogel, Westinghouse Electric & Mfg. Co., and V. M. Montsinger, General Electric Co.

*Factors Influencing the Insulation Coordination of Transformers, F. J. Vogel, Westinghouse Electric & Mfg. Co.

*Coordination of Insulation, V. M. Montsinger, W. L. Lloyd, Jr., and J. E. Clem, General Electric Co.

*Recent Developments in High-Current Mercury-Arc Rectifiers, E. H. Reid and C. C. Herskind, General Electric Co.

*Synchronous-Mechanical Rectifier-Inverter, S. S. Seyfert, Lehigh University.

### Thursday, January 26

**10:00 a.m.—(H) Lightning**

*Impulse Testing Recommendations, Subcommittee on Lightning and Insulators, Philip Sporn, Chairman.

*Lightning Investigation on Transmission Lines—III, W. W. Lewis and C. M. Foust, General Electric Co.

*Lightning Experience on 132-Kv Lines of the American Gas and Electric Company System, Philip Sporn, American Gas and Electric Co.

*Impulse and Dynamic Flashover Studies of 26-Kv Wood Pole Transmission Construction, A. S. Brookes and R. N. Southgate, Public Service Electric & Gas Co., and E. R. Whitehead, Westinghouse Electric & Mfg. Co.

*Operating Experience With Wood Utilized As Lightning Insulation, H. L. Melvin, Electric Bond and Share Co.

10:00 a.m.—(I) Electrochemistry and Electrometallurgy

Address—Increasing Applications of Electricity to Chemical Processes, Colin G. Fink, Columbia University.

*Light Sensitive Industrial Process Control, J. V. Alfriend, Jr., Westinghouse Electric & Mfg. Co.

2:00 p.m.—(J) Instruments and Measurements

A Standard of Low Power Factor, W. B. Kouwenhoven and L. J. Berberich, The Johns Hopkins University.

A Bridge for Precision Power Factor Measurements on Small Oil Samples, J. C. Balsbaugh and P. H. Moon, Massachusetts Institute of Technology.

Skin Effect in Rectangular Conductors—A Method of Measurement and Experimental Data, H. C. Forbes and L. J. Gorman, The New York Edison Co.

*Impulse Voltage Testing, C. F. Harding and C. S. Sprague, Purdue University.

*The Measurement of High Surge Voltages, P. L. Bellaschi, Westinghouse Electric and Mfg. Co.

*Laboratory Measurement of Impulse Voltages, J. C. Dowell and C. M. Foust, General Electric Co.

2:00 p.m.—(K) Industrial Applications

*Circuit Breaker Protection for Industrial Circuits, H. J. Lingal and O. S. Jennings, Westinghouse Electric & Mfg. Co.

*Variable Voltage Equipment for Oil Well Drilling, A. H. Albrecht, Standard Oil Co. of Calif.

*Recent Developments in Electronic Devices for Industrial Control, F. H. Gulliksen, Westinghouse Electric & Mfg. Co.

**Friday, January 27**

10:00 a.m.—(L) Protective Devices

The Use of Communication Facilities in Transmission Line Relaying, J. H. Neher, Philadelphia Electric Co.

Protection of Electrical Apparatus—Recommended Practise, Relay Subcommittee, O. C. Traver, Chairman.

A Sequence Relay for Network Protectors, H. S. Orcutt, United Electric Light and Power Co., and M. A. Bostwick, Westinghouse Electric & Mfg. Co.

Phase Sequence Relaying, H. R. Searing, The New York Edison Company and The United Electric Light & Power Co., and R. E. Powers, Westinghouse Electric & Mfg. Co.

10:00 a.m.—(M) Selected Subjects

Higher Steam Pressures and Temperatures—A Challenge to Engineers, M. D. Engle and I. E. Moultrop, The Edison Electric Illuminating Co. of Boston.

*Actions Taken by the Symbols, Units, and Nomenclature Committee of the International Union of Pure and Applied Physics, A. E. Kennelly, Harvard University.

Empirical Equations for the Magnetization Curve, J. P. Barton, Milwaukee, Wis.

†Tensor Analysis of Rotating Machinery, Gabriel Kron, United Research Corp.

2:00 p.m.—(N) Research and Applied Electronics

The Dielectric Losses in Impregnated Paper, J. B. Whitehead, The Johns Hopkins University.

Applications of Harmonic Commutation for Thyratron Converters, C. H. Willis, Princeton University.

*Ignition of Arcs in Vapor Discharge Tubes, J. Slepian and L. R. Ludwig, Westinghouse Electric & Mfg. Co.

*Capacitance and Loss Variations With Frequency and Temperature in Composite Insulation, H. H. Race, General Electric Co.

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* These papers are under consideration for presentation at the winter convention, but up to date of going to press have not been officially placed upon the program.

† These papers will not be published in advance form by the Institute but copies may be made available by the respective authors.

### Rules on Presenting and Discussing Papers

At the technical sessions papers will be presented in abstract, 10 min being allowed for each paper unless otherwise arranged, or the presiding officer meets with the authors preceding the session to arrange the order of presentation and allotment of time for papers and discussion.

Any member is free to discuss any paper when the meeting is thrown open for general discussion. Usually 5 min are allowed each discusser. When a member signifies a desire to discuss papers on other subjects or groups, he shall be permitted a 5-min period for each subject or group.

It is preferable that a member who wishes to discuss a paper give his name beforehand to the presiding officer of the session at which the paper is to be presented. Copies of discussion prepared in advance should be left with the presiding officer. Each discusser is to step to the front of the room and announce, so that all may hear, his name and professional affiliations. Discussions at the technical sessions are not reported. To be considered for publication, discussions should be written and mailed to the A.I.E.E., Editorial Department, 33 West 39th Street, New York, N. Y., on or before Feb. 10, 1933.

**Electric Railway Association Changes Name.**—At the Annual Business Meeting of the American Electric Railway Association held in Chicago, Illinois, the last week in September 1932, the name of this association was changed to the American Transit Association. It is felt that the new name more accurately indicates the scope of the association's functions and activities and its interest in the transportation business. The change in name has been under consideration for several years. To be consistent with the name of the parent association, the names of the 4 affiliated associations were also changed at that time and are now the American Transit Accountants' Association, American Transit Claims Association, American Transit Engineering Association and American Transit Operating Association.

## Utah Section Offers Prizes for Papers

Prizes amounting to $25 have been offered by the Utah Section for papers presented before that Section by its members, according to announcement at the Section's October 10, 1932, meeting in Salt Lake City, by Dr. J. H. Hamilton, chairman of the Section's program committee. Excerpts from the announcement follow:

"To encourage members of the Utah A.I.E.E. Section to present papers before the local Section the executive committee has voted $25 for prize awards. . . . . first prize $15, second prize $10. Papers are to be judged by 3 judges appointed by the executive committee, and prizes will be awarded at the final meeting of the Section. To facilitate the management, the following rules have been established:

1. "The contest is open to an Institute member of any grade and to any person whose application for membership is in process. Application for admission to the contest is to be made to the Section secretary before November 15, 1932, . . . . . [stating] a tentative title of the paper, the approximate length, and the choice as to date of delivery."

2. "The valuation governing the grading of the Section papers in determining the prize award will be identical with those used by the national committee in determining the award of national prizes."

## Student Conference Held by South West District

A Student conference of the Institute's South West District, No. 7, was held October 21 and 22, 1932, at the University of Oklahoma, Norman. In addition to the 4 members of the faculty and 50 junior and senior students from the University of Oklahoma, there were present 106 from other colleges and the Oklahoma City Section. Attendance of the chairmen and counselors, as shown in Table I, was exceptionally good. The absence of the 3 counselors who were not present was unavoidable.

Two meetings of the Branch counselors and Student chairmen were held. Considerable discussion was centered on the present practise in this District of awarding prizes for student papers other than the Institute's usual national and District prizes for Branch papers. It was felt that an element of unfairness resulted from the fact that some of the colleges in the District required undergraduate research and theses, whereas others had no such requirements. In order to obviate this difficulty a motion was passed to the effect that although technical sessions would be held at future meetings, papers by students of the various Branches would not be put in competition, ranked, or prizes offered for the best paper. Other problems discussed at these meetings included means for increasing attendance, improving interest and making the Student Branch more as an introduction to membership in the Institute after graduation.

Three technical sessions were held, at which 10 Student papers were presented. The paper entitled, "The Development of a Medium Priced High Quality Microphone," by J. D. Martin, Jr., of the Missouri School of Mines and Metallurgy, was decided to be the best paper presented at this session, and his Branch was awarded the bronze plaque offered this year by the Oklahoma City Section. The other Student papers presented were as follows:

Construction of WNAD, by Wilmer Ragsdale and Bryan Cole, Okla. Univ.

Recent Developments in the Metering of Electrical Energy, by M. P. Jones, Southern Methodist Univ.

Transmitters for Broadcast Service, by R. D. Compton, Kansas State Col.

Some Fundamentals of Inductive Coordination, by David Sussin, Texas Univ.

Influence of Voltage Variations on Induction Motor Characteristics, by L. C. Wasson, Arkansas Univ.

Economics of Rural Line Distribution, by B. E. Lowe, Okla. A. & M. Col.

A Device for Demonstrating Symmetrical Components, by Stanley Fish and Austin True, Univ. of New Mexico.

An Ultra Short Wave Transmitter, by G. C. Hutcheson, Texas A. & M. Col.

Comparison of Strowger Type With Panel Type Automatic Telephone Equipment, by R. C. Jackson and L. D. Weiser, Univ. of Kansas.

Table I—Counselors and Chairmen Present

| College | Branch Counselor | Student Chairman |
|---|---|---|
| University of Arkansas | W. B. Stelzner | L. C. Wasson |
| Kansas State College | R. G. Kloeffler | G. D. Ferguson (v-chm.) |
| University of Kansas | D. C. Jackson, Jr. | R. C. Jackson |
| Missouri School of Mines | I. H. Lovett | J. D. Martin |
| University of Missouri | M. P. Weinbach | A. L. Coffman |
| University of New Mexico | | Stanley Fish |
| Oklahoma A. & M. College | A. Naeter | J. R. Hollis |
| University of Oklahoma | F. G. Tappan | H. H. Moody |
| Rice Institute | J. S. Waters | E. F. Kinzer |
| Southern Methodist University | H. F. Huffman | R. P. Lindsley |
| A. & M. College of Texas | H. C. Dillingham | G. H. Samuels |
| Texas Technological College | | Preston Conner |
| University of Texas | J. A. Correll | F. C. Sperry |
| Washington University | | C. E. Keiser |

# Changes Made in A.I.E.E. Prizes for Technical Papers

Authors who plan to present papers before the Institute during the calendar year 1933, those who have presented papers during 1932, and others who may wish to submit papers for prizes, would do well to bear in mind that such papers are eligible for consideration for Institute prizes. These awards are made each spring for the preceding calendar year, and fall into 2 main classes, national and District prizes.

On account of the reduced income of the Institute, the board of directors decided to omit the cash awards for papers presented during the calendar year 1932, except that a payment of $25 in cash will accompany each District Prize for Branch Paper. All certificates will be issued as usual, those for national prizes signed by Institute officers, and those for District prizes signed by the officers of the Districts concerned. In cases of joint authorship, a certificate will be issued to each author.

## National Prizes

The national prizes which may be awarded at the discretion of the committee on award of Institute prizes are as follows:

1. Prizes for best papers in (1) *engineering practise,* (2) *theory and research,* and (3) *public relations and education.*
2. Prize for initial paper.
3. Prize for Branch paper.

The national prize for best paper in each of the 3 classes indicated may be awarded to the author or authors of the best original paper presented at any national, District, or Section meeting of the Institute, provided the author, or at least one of coauthors, is a member of the Institute.

The national prize for initial paper may be awarded to the author or authors of the most worthy paper presented at any national, District, Section, or Branch meeting of the Institute, provided the author or authors have never previously presented a paper which has been accepted by the technical program committee, and the author, or at least one of coauthors, is a member of the Institute or is a graduate student enrolled as a Student of the Institute.

The national prize for Branch paper may be awarded to the author or authors of the best paper based upon undergraduate work presented at a Branch or other Student meeting of the Institute, provided the author or authors are Student Branch members.

All papers approved by the technical program committee which are presented at any meeting will be considered by the committee on award for the prizes for best paper and initial paper without being formally offered for competition. All papers other than those presented to the technical program committee must, in order to receive consideration, be submitted in triplicate with a written communication to the national secretary on or before February 15 of the year following the calendar year in which they were presented. This may be done by the author or authors, by an officer of the Institute, or by the executive committees of Sections, or Geographical Districts.

## District Prizes

The following District prizes may be awarded each year in each Geographical District of the Institute.

1. Prize for best paper.
2. Prize for initial paper.
3. Prize for Branch paper.

A District prize may be awarded only to an author who, or to coauthors of whom at least one, is located within the District, and for a paper presented at a meeting held within, or under the auspices of, the District.

The District prize for best paper may be awarded for the best paper presented at a national, District, or Section meeting, provided the author, or at least one of coauthors, is a member of the Institute.

The District prize for initial paper may be awarded for the best paper presented at a national, District, Section, or Branch meeting, provided the author or authors have never before presented a paper before a national, District, or Section meeting of the Institute, and the author, or at least one of coauthors, is a member of the Institute or a Graduate student enrolled as a Student of the Institute.

The District prize for Branch paper may be awarded for the best paper based upon undergraduate work presented at a Branch or other Student meeting of the Institute, the author or authors of which are Student Branch members.

All papers to be considered in competition for District prizes must be submitted in duplicate by the authors or by the officers of the Branch, Section, or District concerned to the District committee on awards on or before January 10 of the year following the calendar year in which the papers have been presented.

Copies of a pamphlet entitled "National and District Prizes" may be secured, without charge, upon application to Institute headquarters.

# Dr. Langmuir Awarded Nobel Prize in Chemistry

The Nobel Prize in chemistry for 1932 has been awarded to Dr. Irving Langmuir, associate director of the research laboratory of the General Electric Company, Schenectady, N. Y. The award will be presented to him in Stockholm, Sweden, on December 10, 1932.

Dr. Langmuir was born in Brooklyn, N. Y., 1881. He graduated from the School of Mines of Columbia University in 1903 and received his master's degree and that of doctor of philosophy from the University of Goettingen, Germany. Honorary degrees have since been awarded him by several institutions. Between 1906 and 1909 he was instructor in chemistry at the

Stevens Institute of Technology, Hoboken, N. J., and since 1909 has been connected with the research laboratory of the General Electric Company.

One of Dr. Langmuir's early achievements was the development of the high intensity incandescent lamp, the bulb of which contained small quantities of either nitrogen or argon. It has been stated that the cost of energy required for electric lighting in this country has been reduced about 50 per cent by this gas filled lamp. Growing out of this work with the incandescent lamp were important discoveries in the field of the vacuum tube. The vast development of radio broadcasting and the use of the vacuum tube in electrical control operations and similar fields can be traced largely to Dr. Langmuir's discoveries. His discovery of the atomic hydrogen method of electric welding also was of great importance, as this permits the welding of metals which formerly could not be joined. His many published papers are considered by scientists to be of considerable value. Dr. Langmuir has been particularly interested in the mechanism of chemical reactions taking place on solid surfaces and is now working out the laws according to which atoms and molecules distribute themselves over surfaces, forming single layers of atoms. These laws are of importance in understanding many simple phenomena, such as those of the spreading of oil films on water and of lubrication.

Dr. Langmuir has received many previous honors. The Nichols Medal was awarded to him by the New York Section of the American Chemical Society, first in 1915 for his work on chemical reactions at low pressures, and again in 1924 for his work on atomic structure. In 1918 he received the Hughes Medal from the Royal Society of London in recognition of his researches in molecular physics. The Rumford Medal was awarded him in 1920 by the American Academy of Arts and Sciences for the thermionic researches and his gas filled incandescent lamp. The Royal Academy of Lincei, Rome, Italy, presented its Cannizaro Prize to him in 1925; he received the Perkins Medal in 1928 and the Chandler Medal in 1930. Earlier this year *Popular Science Monthly* awarded him its annual medal and honorarium of $10,000. Dr. Langmuir is a past-president of the American Chemical Society and is a member of many scientific organizations.

## So. Calif. Edison Names New Executives

According to news dispatches under date of October 19, the board of directors of the Southern California Edison Company, Ltd., Los Angeles, has named G. C. Ward (M'24) as its president and H. J. Bauer as chairman of the Board.

These new officers will fill vacancies caused by the death in April 1932 of the company's former board chairman, J. B. Miller, and in August of its former president, R. H. Ballard. Mr. Bauer has been an Edison director for some time; Mr. Ward has been a company official for many years.

### Data Concerning Appropriations for the 60 Local Sections of the Institute for the Appropriation Year Ending September 30, 1932

| | Section Membership as of Aug. 1, 1931 | Section Appropriations as of Aug. 1, 1931, as Provided by the Bylaws | Net Amounts Paid to Sections in Accordance With Agreements | Net Savings From Normal Appropriations | Percentages of Normal Appropriations Saved |
|---|---|---|---|---|---|
| 1. Sections that did not indicate acceptance of 10% deduction, but which nevertheless show expenditures of less than the annual appropriation | | | | | |
| Connecticut | 263 | $ 438.00 | $ 264.77 | $ 173.23 | 39.5 |
| Iowa | 62 | 237.00 | 98.49 | 138.51 | 58.4 |
| Lehigh Valley | 271 | 446.00 | 420.37 | 25.63 | 5.0 |
| Nebraska | 55 | 230.00 | 59.72 | 170.28 | 74.0 |
| New York | 3,794 | 4,215.67 | 4,011.23 | 204.44 | 4.8 |
| Urbana | 36 | 211.00 | 50.76 | 160.24 | 76.0 |
| Worcester | 61 | 236.00 | 141.00 | 95.00 | 40.0 |
| 2. Sections that have accepted 10% deduction of normal appropriation but have not yet rendered final report of expenditures for year ending September 30, 1932 (thus indicating a possible additional saving) | | | | | |
| Houston | 71 | 246.00 | *221.40 | *24.60 | *10.0 |
| Lynn | 134 | 309.00 | *278.10 | *30.90 | *10.0 |
| Madison | 55 | 230.00 | *207.00 | *23.00 | *10.0 |
| Seattle | 218 | 393.00 | *353.70 | *39.30 | *10.0 |
| 3. Sections that did not accept 10% deduction and expended full appropriation | | | | | |
| Mexico | 94 | 269.00 | 269.00 | 0.0 | 0.0 |
| Milwaukee | 221 | 396.00 | 396.00 | 0.0 | 0.0 |
| Providence | 80 | 255.00 | 255.00 | 0.0 | 0.0 |
| Rochester | 103 | 278.00 | 278.00 | 0.0 | 0.0 |
| 4. Sections that did accept a deduction of 10% or more from normal appropriation | | | | | |
| Akron | 75 | 250.00 | 225.00 | 25.00 | 10.0 |
| Atlanta | 102 | 277.00 | 249.30 | 27.70 | 10.0 |
| Baltimore | 217 | 392.00 | 352.80 | 39.20 | 10.0 |
| Boston | 513 | 688.00 | 619.20 | 68.80 | 10.0 |
| Chicago | 1,098 | 1,273.00 | 1,145.70 | 127.30 | 10.0 |
| Cincinnati | 168 | 343.00 | 308.70 | 34.30 | 10.0 |
| Cleveland | 274 | 449.00 | 404.10 | 44.90 | 10.0 |
| Columbus | 62 | 237.00 | 213.30 | 23.70 | 10.0 |
| Dallas | 114 | 289.00 | 260.10 | 28.90 | 10.0 |
| Denver | 154 | 329.00 | 296.10 | 32.90 | 10.0 |
| Detroit-Ann Arbor | 310 | 485.00 | 436.50 | 48.50 | 10.0 |
| Erie | 99 | 274.00 | 246.60 | 27.40 | 10.0 |
| Fort Wayne | 80 | 255.00 | 196.70 | 58.30 | 22.8 |
| Florida | 42 | 217.00 | 108.45 | 108.55 | 50.0 |
| Indianapolis-Lafayette | 88 | 263.00 | 236.70 | 26.30 | 10.0 |
| Ithaca | 38 | 213.00 | 191.70 | 21.30 | 10.0 |
| Kansas City | 158 | 333.00 | 299.70 | 33.30 | 10.0 |
| Los Angeles | 477 | 652.00 | 576.45 | 75.55 | 11.5 |
| Louisville | 53 | 228.00 | 205.20 | 22.80 | 10.0 |
| Memphis | 53 | 228.00 | 265.20 | 22.80 | 10.0 |
| Minnesota | 96 | 271.00 | 243.90 | 27.10 | 10.0 |
| Montana | 26 | 201.00 | 170.59 | 30.41 | 15.0 |
| Niagara Frontier | 176 | 351.00 | 315.90 | 35.10 | 10.0 |
| North Carolina | 83 | 258.00 | 89.89 | 168.11 | 65.0 |
| Oklahoma City | 64 | 239.00 | 215.10 | 23.90 | 10.0 |
| Philadelphia | 760 | 935.00 | 841.50 | 93.50 | 10.0 |
| Pittsburgh | 724 | 899.00 | 809.10 | 89.90 | 10.0 |
| Pittsfield | 137 | 312.00 | 280.80 | 31.20 | 10.0 |
| Portland | 121 | 296.00 | 266.40 | 29.60 | 10.0 |
| St. Louis | 256 | 431.00 | 374.83 | 56.17 | 13.0 |
| San Antonio | 65 | 240.00 | 216.00 | 24.00 | 10.0 |
| San Francisco | 460 | 635.00 | 571.50 | 63.50 | 10.0 |
| Saskatchewan | 39 | 214.00 | 192.60 | 21.40 | 10.0 |
| Schenectady | 456 | 631.00 | 567.90 | 63.10 | 10.0 |
| Sharon | 111 | 286.00 | 257.40 | 28.60 | 10.0 |
| Southern Virginia | 85 | 260.00 | 216.67 | 43.33 | 16.0 |
| Spokane | 46 | 221.00 | 198.00 | 22.10 | 10.0 |
| Springfield | 99 | 274.00 | 137.00 | 137.00 | 50.0 |
| Syracuse | 68 | 243.00 | 218.70 | 24.30 | 10.0 |
| Toledo | 87 | 262.00 | 217.21 | 44.79 | 17.0 |
| Toronto | 388 | 563.00 | 402.06 | 160.94 | 28.0 |
| Utah | 58 | 233.00 | 209.70 | 23.30 | 10.0 |
| Vancouver | 91 | 266.00 | 239.40 | 26.60 | 10.0 |
| Washington | 183 | 358.00 | 322.20 | 35.80 | 10.0 |
| 5. Section Inactive During the Year 1931–32 | | | | | |
| Birmingham | | | | | |
| Total Sections—60 | | 24,943.67 | *21,656.39 | *3,286.38 | *13.2% |

* Tentative figures pending receipt of reports from Sections listed in Item 2.

# 55 Sections Have Assisted in Meeting Reduced 1931–32 Budget

BECAUSE of the reduced income of the Institute, the board of directors at its meeting held on October 23, 1931, adopted a budget of proposed expenditures for the year 1931–2 materially lower than normal, and invited the Sections to cooperate with the board by keeping their expenditures at least 10 per cent below the amounts which would have been available under the provisions given in the bylaws. The board of directors requested that a statement be published after the close of the year giving full credit to all Sections for their cooperation and showing the percentage of reduction attained by each. This information is given in the accompanying tabulation.

The splendid cooperation extended by a large majority of the Sections is sincerely appreciated and has been of great assistance in the efforts to reduce Institute expenditures wherever practicable without interfering seriously with any of the activities.

# Summarized Review of Baltimore Meeting Discussions

PRINCIPAL discussions of the Baltimore Meeting papers are summarized herewith. The papers to which these discussions refer were abstracted in ELECTRICAL ENGINEERING for September 1932, p. 659–62. Only discussion submitted in writing in accordance with governing A.I.E.E. rules is summarized. Complete discussion, together with all approved papers, will be published in the TRANSACTIONS.

## POWER CABLES

R. J. Wieseman (Passaic, N. J.) discussed the historical background of submarine cable installation, leading up to the 115 kv Columbia River crossing. He felt that these recent installations of long-length high-voltage cables should be a source of comfort and encouragement to the utilities in solving their future transmission problems. Cable manufacturers have eliminated the cable as the "neck in the bottle" of best design of large, high voltage power transmission system.

*Thermal Transients and Oil Demands.*—F. H. Buller (Schenectady, N. Y.) in his discussion of this subject expressed the belief that all who have occasion to make temperature-transient or oil-demand calculations on cables are indebted to the authors for the simplifications which they have devised to render computations less laborious. The discusser had found charts 1 and 2 of the paper useful in obtaining approximate values of the roots of equation 6. He believed their limitations were in the mechanics of reproduction rather than in the underlying theory. The method of evaluating the coefficient $c_n$ described by the authors was believed to be simple in theory and usually useful in practise, particularly if only 3 terms of the infinite series for temperature and oil demand are required. He suggested a mathematical solution and presented equations for use in cumbersome cases where more than 3 terms are required.

E. A. Church (Boston, Mass.) also discussed this subject. One of the important facts that he emphasized was that the temperature and oil demand equations for load suddenly applied (unit function in Heaviside terminology) are functions of the constants of the cable only. A graphical method was described that facilitated evaluation of the integral and overcomes the practical difficulties encountered in solving for the coefficients and exponents of each term of the series.

Another discussion by R. J. Wieseman expressed appreciation for the completeness of the analysis of this subject and the excellent charts developed to simplify the labor of making calculations of thermal transients or oil demands. Researches have shown internal pressures in solid cable to be much higher than realized. High pressures have been formed at the conductor and sheath without indication of a positive pressure in the middle of the insulation. This has not been fully understood, but Mr. Wieseman believed that a mathematical analysis along the lines of this paper might offer an explanation.

*Traveling Wave Voltages.*—L. V. Bewley (Pittsfield, Mass.) in discussing this paper expressed the belief that, when taken in conjunction with an earlier paper dealing with the experimental work, it formed a comprehensive treatment of the problem. He suggested and illustrated with equations several ways for increasing the generality of the paper.

J. E. Clem (Schenectady, N. Y.) discussed this subject and analyzed the voltages set up in a cable at the end of a transmission line by the impact of a traveling wave. Calculations were made in two ways: one on the basis of lumped capacitance, the other taking into account the distributed constants of a cable. A comparison of these calculations and a comparison with the test results indicated that the need of cable protection can be determined by calculations made on the basis of lumped capacitance. It was recommended that any cable installation less than 4,000 ft in length be checked to determine the possible need of protection. If the cable at the exit end is connected to a transformer, or a very high surge impedance, protection should be applied.

## TELEPHONE CABLES

*Electrical Testing in Wire Plants.*—W. A. Del Mar (Yonkers, N. Y.) in discussing this subject described some of the early methods of testing in electric wire manufacture and advocated the use of high frequency alternating current. He asked the authors why a frequency of a few hundred cycles was used when by the use of higher frequencies shock hazard could be avoided, a spark of greater searching ability obtained, and the necessity of grounding the wire avoided. He regarded the high frequency spark as especially useful in finding "pinholes" or other air openings in the insulation, but not reliable as a test for the dielectric strength of a patch.

Another discusser, R. J. Wieseman (Passaic, N. J.) inquired as to the speed at which the wire travels through the testing outfit, the voltage and time values used in making the water test, and the limiting thickness of insulation that could be adequately tested by the spark method.

*Pulp Insulation.*—W. A. Del Mar (Yonkers, N. Y.) discussed this subject and inquired concerning the flexibility of this insulation when applied in layers as heavy as 50 mils or more. In regard to the authors' suggestion of new applications, he asked if any of these had materialized in the interim since the writing of the paper.

R. J. Wieseman (Passaic, N. J.) asked about the nature of the wood pulp now used, with special reference to the possible use of spruce fiber. He also asked if the method of insulating the conductors and assembling would result in a firmer cable. In regard to the antimony-lead sheaths of telephone cables, he inquired if pure lead had been considered for cases where the cable is drawn into ducts.

L. S. Ford (Kearny, N. J.) explained that pulp insulated wire fitted very well into the unit idea of cable layup. The construction has been standardized for 24-gage as well as 26-gage pulp cable and it is just being applied to 22-gage pulp cable. Pulp has not as yet resulted in a new line of cable, but in a new type of an existing series of Nos. 24 and 26 exchange area cables that are lower in first cost and that compare very well in quality with the ribbon-insulated cables which they displace. He predicted that in the future, advantage will be taken of the considerable range of values in weight and diameter admitted by pulp.

*Use of Cables for Telephone Distribution Purposes.*—J. A. Cadwaller (Pittsburgh, Pa.) discussed this subject and described a buried cable distribution system recently installed in a high class residential development near Pittsburgh. The land company reserved a 10-ft strip along the rear property line for the utilities, provided trenches for the cables and excavations for the splicing boxes. Conduits from the houses to the nearest splicing boxes were provided by the individual property owners. The telephone company furnished and installed tape armored distribution cable, splicing boxes, terminals, and 1- or 2-pair lead covered cable from the splicing boxes to the houses. The entire cost of this distribution system to the telephone company closely approximated the estimated cost of an aerial cable job on jointly occupied poles.

L. F. Cromwell in his discussion in connection with this subject emphasized the importance of careful cable-pair multiplying in the design of the cable plant so as to effect a minimum plant investment and minimum annual charges consistent with good service. The real test, he thought, is not encountered when the installation is first completed, but rather when service has increased to such an extent that the cable had a majority of its pairs in use.

Another discussion by C. L. Garrett gave consideration to factors which may tend to reduce the intelligibility of speech reception such as noise, crosstalk, and distortion. He pointed out that these factors must be considered and allowance made for them in the design of the plant.

### Economic Aspects of Water Power

A. E. Bauhan (Newark, N. J.) stated that the paper on this subject treated the relative economies of water and steam power in a thorough and sound manner. One of the points brought out in this discussion was in connection with the introduction of the time element, which brings with it the uncertainties of future loads and future competitive plant costs. The curves in the paper, plotted on the basis of percentage of capacity installed, may show a hydroelectric cost, after the initial development, materially below the hydroelectric value and one must not draw from them the conclusion that the project is economically justified. The discusser suggested going a step further and plotting hydroelectric costs and hydroelectric value against years.

William McClellan (New York, N. Y.) pointed out some of the merits of the same paper. He recommended the reading of the paper by every young engineer, not only for the immediate subject of the discussion, but also for the method the author used which, he said, gives a comprehensive treatment of a most intricate subject.

R. E. B. Sharp (Philadelphia, Pa.) in his discussion of the paper considered the performance obtained by the dual operation of pumps and turbines. He considered the case of the design of a centrifugal pump provided with short vanes having a large angle between these vanes (at discharge) and the tangential. When operating as a pump the losses due to diffusion, caused by too great an angle between the vanes, and consequently too great a rate of area expansion, would result in relatively low efficiency as a pump. However, the steep vane angle and short passages would tend to give relatively high efficiency as a turbine. He thought that there was no basis for the efficiency of any centrifugal pump necessarily being the same when operating as a pump as when operating as a turbine.

J. E. Stewart (Pittsburgh, Pa.) considered that the paper clearly brought out the modern conception that the main value of the utility hydroelectric plant, where there is not a high minimum stream flow, was its capacity. He felt that, unless the flow at hydroelectric stations was backed by natural storage or relatively low cost artificial storage, energy costs for hydroelectric plants usually could not compete with energy from modern steam stations.

Another discussion by Ireal A. Winter (Birmingham, Ala.) called attention to the value of this paper, particularly the part dealing with hydroelectric regeneration equipment. He believed the time is fast approaching when the conception of a wide use of hydroelectric regeneration will mature into a concrete fact.

### Safe Harbor Project

J. R. Baker (Baltimore, Md.) in his discussion of this subject drew attention to the progress in hydroelectric design that has occurred in recent years. A comparison of this plant with the Holtwood plant designed some 20 years earlier showed a striking economy of building volume in the design of the Safe Harbor plant. By more skillful arrangement the building mass and structure also were applied to better purpose. The great advance in hydraulic design was well illustrated by the fact that the controlled water path through the Safe Harbor plant, not withstanding its smaller dimensions, is twice as long horizontally as that in the Holtwood plant.

F. H. Hollister (Chicago, Ill.) in connection with this subject cited the advantage of flat efficiency curves and the advances made in steam turbine and boiler room efficiencies during the last 10 years. He believed that this has made imperative the improvement of the over-all all-day efficiency of the hydroelectric station or else greatly reduce the investment permissible in a low head hydroelectric plant. He also referred to the wisdom of making provisions for automatic bus protection.

A. H. Hull (Toronto, Canada) discussed several features about the development, in order to bring out at greater length some of the considerations that led to the construction adopted. He was impressed with the thorough manner in which the many design problems had been handled, and with the result of a superstructure of pleasing appearance that permitted a compact arrangement of major equipment.

Another discussion by A. B. Lakey (Philadelphia, Pa.) described the construction of the 82-in. pivoted-segment thrust bearings for the Safe Harbor units. These thrust bearings carry a load up to about 750 tons apiece with a resulting unit pressure of 416 lb per sq in. on the 3,600 sq in. net of babbitted bearing-shoe surface. The novelty of the design consists mainly in the ease of vertical adjustment at any time, and in the minimum disturbance of other parts of the unit incidental to inspecting or changing the bearing surfaces.

C. F. Merriam (Baltimore, Md.) described the Safe Harbor governing system, which in many respects represents a distinct advance in power plant design. Operation of the turbines has been concentrated on a single floor by locating pumps and actuators on the same level, with a resultant saving in personnel. The twin system located in the space between the two units of each pair eliminates long lines of piping. The protective devices and annunciator system also were described. Impulses from the respective relays not only indicate the source of trouble, but also act upon certain safety devices arranged to produce the desired effect upon the governor.

J. E. Stewart (Pittsburgh, Pa.) in his discussion of this subject expressed a belief that the outstanding feature of the Safe Harbor development was the engineering study that had been devoted to it, and the fact that so many of the results of these studies were incorporated in the actual construction.

Another discussion by R. L. Thomas (Baltimore, Md.) interestingly revealed the history of this development from the time of the first individual flow rights, which dated back to 1902, up through the selection and acquisition of the present site. Early economic studies by the regular operating staff without any publicity and without outside aid prior to making of core borings at the dam site resulted in relatively low costs of property and flow rights as well as for preliminary engineering and organization work. The pre-license cost, exclusive of property, amounted to less than one per cent.

In addition to the foregoing discussion of this development, P. M. Hess, station superintendent at Safe Harbor, outlined the operating experience with the major pieces of equipment thus far obtained from the 10 months' period operation.

*Safe Harbor-Westport 230-Kv Transmission Line.*—H. S. Phelps (Philadelphia, Pa.) in his discussion made a comparison between this line and the Philadelphia Electric Company's 220-kv lines which have essentially the same electrical design features. He presented operating data on the latter lines and suggested a comparison of operating results between these lines. He believed such a comparison should make possible the forming of conclusions better than those presently held concerning the influence on line performance of insulator spacing and string length, size and location of ground wires, and phase wire spacing.

C. L. Fortescue (East Pittsburgh, Pa.) discussed the early considerations that entered into the design of this line. He explained that in the design of transmission lines a compromise must be made between what can be done regardless of cost and what can be considered as economically justified. He believed the author had effectively reached such a compromise as indicated by the performance during the past year.

*Safe Harbor Kaplan Turbines.*—E. Brown (Montreal, Canada) discussed this subject and raised questions concerning several points about the paper. One of these concerned the curves in Fig. 6 which he believed showed large differences between the values of $\Sigma$ at which the efficiency begins to decrease and the unit quantity to increase. He believed that the points of increase or decrease were not well defined. The authors' statement that "the value of $\Sigma$, at which efficiency and discharge were found to break, was taken as the cavitation limit for that particular speed, head, and gate opening" seemed to the discusser to imply a much closer agreement between $\Sigma$ values than that shown in Fig. 6.

In connection with the cavitation experiments, J. A. Peck (Boston, Mass.) asked what means were employed to isolate the phenomenon of the efficiency break so that it could be positively attributable to the cavitation rather than to some other coincidental factor, such as a crisis in the flow conditions within the particular type of draft tube in use.

R. E. B. Sharp (Philadelphia, Pa.) discussed the cavitation problem and referred to an installation in Canada that furnishes an interesting example of the ability of a turbine to operate without serious pitting with a value of Σ so low as to result undoubtedly in the formation of continuous cavitation without sufficient pressure to cause the collapse of the cavities. A curve was presented which represented roughly the limit in value of Σ for the usual modern propeller runner designs.

Messrs. L. B. Stirling and J. B. MacPhail (Montreal, Canada) asked if the possible occurrence of pitting in the draft tube was examined by paint tests. The pitting of a painted surface in a model draft tube is believed to be a good indicator of erosion of concrete on the full sized installation. This relation has been proved to be correct in at least 2 cases.

Another discusser, H. S. Van Patter (Montreal, Canada) inquired, in connection with the tests, as to why it was considered necessary to hold the total head constant when varying the suction head and asked if that decision had been confirmed by test results. In other words had tests shown that the cavitation point was affected by variations in total head?

### LOW HEAD HYDROELECTRIC DEVELOPMENTS

L. F. Harza (Chicago, Ill.) in his discussion of this paper questioned the general desirability of using special Kaplan wheels on horizontal shafts, such as shown in the author's Fig. 26. He pointed out that the draft tube problem is complicated, the building width greater, and that high tailwater requires design of the generator room walls for outside pressure, and the use of drainage pumps to remove leakage.

H. E. Popp (Boston, Mass.) discussed this subject from a point of view different from that taken by the author. He did not agree that credit for past accomplishment in the field of economical low head developments was due entirely to European engineers. It was pointed out that the so-called Kaplan turbine in reality is the use of the adjustable-blade runner and its control mechanism in combination with the usual form of scroll case, draft tube, and miscellaneous mechanical details independently developed and perfected by American engineers. He also believed that there was grave danger that overemphasis of some particular phase of design, such as the cavitation problem, might lead to the introduction of costly practises that are not justified by the ends obtained. In this connection he did not agree with the practise to machine and polish all runner blade surfaces in contact with flowing water, especially since this has no effect on efficiency.

J. W. Rickey (Pittsburgh, Pa.) was of the opinion that the future development of hydroelectric projects of low and medium head in the United States depended upon obtaining lower plant cost through greater economy in the design of both plant and equipment. This, he believed, could be achieved only when the manufacturer and the user of turbines adopt a radically different attitude toward the scientific side of concurrent turbine design and laboratory tests.

F. H. Rogers (Philadelphia, Pa.) in his discussion presented considerable of the history of the development of the propeller turbine, in particular, the achievements made in the United States. He referred to the Great Falls development of the Manitoba Power Company undertaken in 1921 when the Dominion Engineering Works, Ltd., proposed I. P. Morris propeller turbines of 28,000 hp unit capacity for a head of 56 ft. At that time a cavitation theory for the propeller turbine was developed utilizing data from marine propeller experience. He also referred to the early work of L. F. Moody, an American engineer, who first demonstrated that for a head range more than double that previously attempted, equal or greater efficiencies with freedom from cavitation could be secured by the use of large areas for the blades.

In connection with this subject R. V. Terry (Newport News, Va.) told of a new type of adjustable propeller turbine now in the process of development. The vanes of the runner are adjusted automatically by the water flow, assuming the most efficient angle for any head and for any load within the capacity of the turbine.

## John Fritz Medal for 1933 Awarded

The John Fritz Gold Medal for 1933 has been awarded to Daniel Cowan Jackling for "notable industrial achievement in initiating mass production of copper for low grade ores through application of engineering principles." The award was made by a board of 16 representatives of the 4 national engineering societies.

Mr. Jackling is the twenty-ninth engineer to receive the John Fritz gold medal, which is awarded not oftener than once a year for notable scientific or industrial achievement without restriction on account of nationality or sex. It is a memorial to the late John Fritz, a leader in the American iron and steel industry; the first medal was awarded to Mr. Fritz in 1902 in celebration of his eightieth birthday. Members of the Institute who have received this medal include: Elihu Thomson (A'84, F'13, HM'28, member for life, and past-president); Guglielmo Marconi (HM'17); Ambrose Swasey (HM '28); Edward D. Adams (A'10); Elmer A. Sperry (M'29); John J. Carty (A'90, F'13, HM'28, member for life, and past-president); Herbert Hoover (HM'29); and M. I. Pupin (A'90, F'15, HM'28, member for life, and past-president). Other John Fritz medalists, no longer living, include: George Westinghouse (A'02); Alexander Graham Bell (A'84, M'84, and past-president); and Thomas A. Edison (A'84, M'84, HM'28).

Mr. Jackling was born at Appleton City, Mo., in 1869 and was graduated from the Missouri School of Mines in 1892. After spending a few years in teaching and in technical work in connection with mining operations he turned his attention to construction and operation of metallurgical works and embarked upon his notable career in that field as a pioneer in mass production of copper from low grade ores. The improvements in the production of copper conceived and originated by Mr. Jackling have resulted in a great increase in the world's production of copper, and a reduction in its cost. The electrical industry, as well as many other modern industries, are greatly indebted to Mr. Jackling for these improvements in the production of copper.

Mr. Jackling was director of explosives for United States government during the World War and in this capacity performed distinguished service. He is also esteemed in many sections of the western United States for his interest in the communities which under his direction have been built up at the properties of which he is the head. He is president and director of several copper mining and related companies. For his public and industrial services he has been honored by the distinguished service medal of the United States Government in 1919, the gold medal of the Mining and Metallurgical Society of America in 1926, and the William Lawrence Saunders gold medal of the American Institute of Mining and Metallurgical Engineers in 1930.

## Noted Engineer Honored on Retirement

Robert Ridgway, chief engineer of the board of transportation of the City of New York, N. Y., retired on November 1, 1932, after having worked for the city for 48 years. On the date of his retirement he was the guest of honor at a dinner given at the Engineers' Club by 105 leading engineers of the country. A feature of this event was Mr. Ridgway's tribute to those who had worked with him during this period.

Mr. Ridgway was born in Brooklyn, N. Y., in 1862. Although he secured his education in the public schools of Brooklyn and at home, he has received honorary degrees of M.S. in C.E. from New York University in 1915, A.M. from Harvard University in 1925, and doctor of engineering from Lehigh University in 1929. After spending 2 years with the Northern Pacific Railway as chainman, rodman, and leveler in Montana and Wisconsin, he entered the employ of the aqueduct commission of New York City in 1884 and remained with the city from that time until his retirement. During this period he has supervised the construction of many of the city's subways and elevated lines and built many of the tunnels and aqueducts which have been of such tremendous importance to the development of this city. He has also been a member of the Chicago Traction and Subway Commission, chairman of the board of engineers for the Transbay Bridge, San Francisco, Calif., member of the Colorado River Board of the United States government, Hoover Dam Project, consulting engineer for the Japanese Government Railways and to the cities of Tokio and Osaka, and consulting engineer on subways for the City of Chicago. Mr. Ridgway is a member of several engineering and scientific societies and is a past-president of the American Society of Civil Engineers.

# Unemployment Relief Plans Throughout Country Progressing

CONSIDERABLE experience in means for alleviating unemployment and providing relief to the more destitute members of the engineering profession was gained during the winter 1931–32 by many Sections of the Institute. This experience is proving of great assistance in the formulating of plans for relief to engineers during the coming winter, and should make the 1932–33 efforts even more effective than those of last winter. A summary of the activities of some of the Institute's Sections during the past winter was given in ELECTRICAL ENGINEERING for November 1932, p. 809–13.

For the coming winter, most of these sections report that the activities planned are similar in scope to those of last year, although changes are being made in the methods of securing work and of providing financial assistance. Sections generally have found that the conducting of surveys of industrial organizations in their community, for the purpose of determining positions which might be filled by men on the unemployed list, have produced meager results. However, where an energetic campaign has been conducted to create new positions in industry and to "sell" business organizations of all sorts, including the wholesale and retail distributing units, even department stores, on the idea of using engineers in positions for which it was not previously realized that they were valuable, the results have been surprisingly successful. The possibilities of extending this type of work are realized by many of the Sections, and others doubtless would do well to give consideration to its possibilities.

In most localities the Institute Sections are cooperating with the local Sections of the other engineering societies in assisting the local civic organizations that are providing relief to the entire community. One of the most important lessons that was learned last year in the localities where this type of relief was attempted is that the engineers must, themselves, remain active on the civic relief groups, in order to insure that the members of their own profession secure their proper proportion of relief. This has been found to apply not only to providing employment, but also to the provision of financial assistance to those for whom no employment is found. The importance of this phase of the work needs to be emphasized in many communities. The local civic bodies carrying on the general relief work are almost universally capable and anxious to be impartial. However, activities of other groups require that out of loyalty to their profession, Sections of the Institute should secure representation on these civic bodies, and should add their voices to secure a fair distribution of relief to all industrial groups.

In the campaign for funds to be used this winter, an effort is being made in several communities to increase the number of contributors to these funds, rather than to increase the amount of individual contributions. The fairness of this plan needs no comment here. Willingness is being shown also by those still employed to cooperate in the plans for spreading work among the largest number possible and thus reduce cases of extreme hardship. The larger cities, of course, are the most active in providing unemployment relief because it is in those communities that the greatest need occurs. It is in the larger cities, however, that the greatest difficulty is encountered in making contact with needy cases. In the smaller communities, especially those not having many industries, concerted action by engineers has been found almost unnecessary, partly because more intimate contact between members of these communities is possible and partly because those requiring assistance are more likely to be aided by their friends and acquaintances.

Letters have been received from many Sections of the Institute, outlining the plans for the coming winter. Some of these are summarized or printed in full in the following paragraphs in the hope that a circulation of these ideas may be of assistance to other Institute Sections.

## NEW YORK CITY

In the metropolitan area of New York, N. Y., the local Section of the Institute is acting through the Professional Engineers Committee on Unemployment, the activities of which last year were presented in some detail in ELECTRICAL ENGINEERING for November 1932, p. 809–11. Activities for 1932–33 were started by the chairmen of the New York Sections of 4 national engineering societies getting together and deciding upon the work to be done. An organization was formed with Rear Admiral Frederic R. Harris, retired, as general chairman. H. deB. Parsons, who was general chairman last year, is serving this year as chairman of the advisory committee. As last year, United Engineering Trustees, Inc., is acting as treasurer. The working committees for the coming year are as follows: *finance committee,* T. F. Barton (A'12, F'30), chairman; *relief committee,* Ole Singstad, chairman; *publicity committee,* E. E. Dorting (A'13, M'22), chairman; and *clearance committee,* Alfred D. Flinn, chairman.

One change from last year is in providing for contributions to be paid in weekly payments extending over a period of 20 weeks, in addition to the alternative of making donations in 5 monthly payments as was provided last year. Following are excerpts from a statement made by the chairman of the New York Section of the Institute.

"The incoming committee is impressed with the organization developed last year, and realizes fully the successful outcome of their efforts in providing relief to engineers in the [N. Y.] metropolitan territory during 1931–1932. The plans for this year's operations will not depart from those of last year, and with the early start made we expect to accomplish as much as last year, and hope to do even more, since we are convinced that the demand this year will exceed that of last year. The united effort of local sections of 4 engineering societies in this work results in a unity of purpose and in efficiency and economy in handling the work. We feel that we are able to accomplish our objectives by providing:

"1. A suitable place for the registration of unemployed engineers, both members and non-members of the societies.

"2. An organization for the soliciting of funds to be used entirely for relief purposes.

"3. Establishing contacts with other relief committees in the community and in this way obtain temporary employment for a large number of the men registered with us.

"Our registrants are primarily interested in obtaining work, and it is gratifying that by far the larger part of our relief comes as a result of obtaining employment for these men. Last year for each dollar expended by the Professional Engineers' Committee on Unemployment in direct relief, a total of approximately $6 was paid to our registrants for work created by other relief organizations in the community and paid for by them. (Editor's Note: Efforts of the P.E.C.U. in securing for engineers a proper proportion of the relief afforded by the Emergency Unemployment Relief Committee of New York City has been an important phase of the work and is one that can be duplicated easily in any community.) This year we are assured of the hearty cooperation of other relief agencies, and if possible this year we should like to increase the 6:1 ratio to an even higher figure.

"Contributions from our members and friends to date are in line with last year, and we are confident that our membership with the full realization of the problem at hand will respond liberally so that the total amounts collected for the year will be gratifying, not only to the committee but to the membership at large."

## PLANS OF SOME OTHER CITIES

Excerpts of letters received from some other of the sections follow. In presenting this information an effort has been made to include suggestions for the coming year. It is felt that records of last year's accomplishments, however important, were covered to a considerable extent by the article in ELECTRICAL ENGINEERING for November 1932, p. 809–13, previously referred to.

The relief program in Boston, Mass., undertaken by the Emergency Planning and Research Bureau, Inc., was reported in some detail in ELECTRICAL ENGINEERING for November 1932, p. 811–12. The following statement of the Honorable Joseph B. Ely, Governor of Massachusetts, indicates the value of this work: "Several of the state boards lack the necessary funds for obtaining information which is very desirable for the conduct of their work. The Emergency Planning and Research Bureau has taken over this work, and has already furnished the state agencies valuable data which would not otherwise have been available." Of interest also is the following statement of Philip Cabot, head of the department of public utilities, graduate school of business administration, Harvard University: "You (the members of the engineering and architectural societies of Boston) have recognized better than others that the cost of planning is far less than the expense of correcting errors and of living with mistakes; that the losses imposed by uncoordinated, sporadic, and parochial development will not long be tolerated, and that when the time comes for broad planning, facts must be available on which it can be based. You have grasped the fact that slack times should be used for compiling and interpreting facts which will be needed in busier periods. You have properly confined your work to the collection of those facts which will be essential to those organizations which in the future must plan the development of this crowded district."

From the Philadelphia Section: "Our experience indicates a campaign for raising funds by the affiliated societies for the purpose of relief should be carefully approved and an organization established thoroughly in accord with the project before launching into the campaign. One of the chief difficulties is personally contacting the membership. Taking Philadelphia for illustration, the members reside throughout Philadelphia and the suburbs, part of Pennsylvania, New Jersey, and Delaware. Subscription cards were prepared with the name and address of members and for the A.I.E.E. were arranged by firms and by geographical location, so as to facilitate the work of soliciting on the part of those members on the fund raising committee. It was not possible personally to contact the membership outside of Philadelphia and the immediate suburbs. In these cases, an appeal was made by letter. The most effective way to raise funds is through official endorsement and solicitation being carried on among the technical employees by the firm; next is by personal contact, the smallest contributions being received in amount as well as in number by letter."

Also, the following is taken from an article describing the work of the Philadelphia Technical Service Committee (see ELECTRICAL ENGINEERING for November 1932, p. 813 and July 1932, p. 526): "Too little emphasis ordinarily is placed upon the necessity for providing useful work for these unemployed to perform along the general lines of their experience and capabilities. After a man has been out of work for an extended period and has tramped the streets in a useless endeavor to find a job, he begins to lose confidence in himself and in his profession, and he needs the kind of job which requires him to use his brain and to employ the experience which he has acquired in previous positions."

Funds raised by the Pittsburgh Section, totaling $646.25 for the months of June to October, inclusive, 1932, are turned over to the Engineers' Relief Committee of Pittsburgh which, as of the first of November 1932, had raised approximately $11,000. Distribution of these funds, as of May 28, 1932, was reported in ELECTRICAL ENGINEERING for November 1932, p. 813, and is divided between loans and contributions to individuals. It is stated that "it is planned to continue the work during the winter in much the same way as it has been handled in the past. The relief work has done a great deal of good, although it is on a small scale, since it has helped men who would probably not have received help through the ordinary relief channels."

From the Dallas Section: "The Dallas Section has no formal program of unemployment relief activities to be undertaken during the coming winter. It is not thought that a formal program here can be justified, because of the relatively small number of unemployed engineers and of the comparatively few opportunities in this Section's territory for additional technical employment. The members of Dallas Section as individuals cooperate with the local civic relief organizations, which have under way now a drive for funds."

From the Spokane Section: "Our program for unemployment relief for the coming winter will be the same as that practised last year. This consisted of cooperating with the local group of Associated Engineers. This organization is comprised of engineers of all branches and holds weekly noon-day meetings. Their unemployment committee is composed of a representative from each of 4 local sections of national societies. This committee has functioned satisfactorily in the past. It has been instrumental in locating jobs for numerous men. Its members have contacted many employers to whom they have told the story of why engineers should be employed in almost any line of work because their training as engineers has fitted them for work over a broad range. At present there are practically no unemployed electrical engineers who are members of this section. They have found work in various other lines, especially commercial."

### INDEPENDENT ACTION TAKEN BY SAN FRANCISCO SECTION

From the San Francisco Section: "Our activity in San Francisco has been purely within our own Section. The other societies in San Francisco have so far as I know taken care of their own members. This plan has worked very well here. It is in keeping with the suggestions of President Hoover as regards national relief and that is that each community take care of its own needy. It has proved very efficient and without waste. The collection of the relief fund is based upon an administrative period of 6 months. Actual experience in the operation of the fund during the first 6 months showed a surplus and it was decided to carry this surplus over into the fall and winter period rather than return it to the original donors, this on the theory that the unemployment situation would become more acute at that time. Accordingly, the fund was divided into 2 parts, a small amount being held for current necessities and the balance placed in a savings account. No attempt was made to collect delinquent pledges, and voluntary contributions were discouraged. We, therefore, find ourselves in a position to enter the fall and winter period with a reserve fund on hand, and anticipate no difficulty in meeting possible drains upon the fund through a revival of the pledges and voluntary subscriptions. We are particularly fortunate in San Francisco in the rather close affiliation among the members of the 4 principal engineering societies; for instance, through the interlocking directorship of the San Francisco Branch of the Engineering Societies Employment Service. Unless the situation proves exceedingly difficult, we look forward to carrying on through the winter season with a fair degree of success through the operation of the relief fund. The funds are in the hands of a trustee and are administered separately from the funds of the San Francisco Section of the A.I.E.E."

From the Atlanta Section: "The Atlanta Section was instrumental in having an executive committee consisting of the chairmen of the electrical, mechanical, and civil engineers and architects to consider this (unemployment) problem. This executive committee has been in operation approximately 9 months, and has been instrumental in assisting engineers to find employment within our district. If an engineer needs assistance the matter is brought to the attention of this committee and a very definite effort is made by us to find part time employment or some other means of assistance. The situation in regard to engineers in Atlanta and Georgia has not been as severe as in other states. Most of the firms in this vicinity have cooperated on the basis of sharing the engineering work. For instance, a company employing quite a number of engineers have reduced their work to a half-time basis so that as many engineers as possible could be given a livelihood. Also, a number of engineers that were released have found employment in other lines within the state. I do not mean to imply that we are in a position to absorb additional engineers in this district, but do feel that we have been instrumental in assisting engineers in keeping in employment. We have not given very much publicity to this activity rather depending upon the members of the Societies mentioned above to bring to our attention worthy cases. So far we have confined our assistance to members of the societies mentioned above, but in case of a worthy cause we would also assist an engineer not affiliated with one of these societies."

### 4 PER CENT LOANS MADE BY PORTLAND SECTION

The Portland Section, as outlined in ELECTRICAL ENGINEERING for November 1932, p. 813, is working with the Oregon Technical Council in making loans to engineers at 4 per cent interest. Further information from this Section follows: "At present we are soliciting subscriptions for funds to be used for loans this winter as our balance is getting low and only one note has been repaid. Last year we had relatively few large subscriptions, but this year we are trying to get a large number of small subscriptions. The local section of each founder society solicits the funds and pays all expense of the solicitation, while the administration and expense of handling this fund is paid by the Oregon Technical Council. In conjunction with this loan fund, we have an employment committee which has been successful in placing many engineers in such places as timekeeper, foremen on construction jobs, watchmen, and many other jobs."

From the Milwaukee Section: "All of the work of the Milwaukee Section of the A.I.E.E. has been in connection with the work done by the Engineers Society of Milwaukee, with which we are affiliated. The Engineers Society has appointed a special investigator to collect information on the unemployment of engineers, through questionnaires among the members and through personal solicitation regarding the possibilities of work among employers. The result of this work has been to show that approximately 150 engineers are without employment at the present time. A recent secondary questionnaire determined that, among these 150, only 2 are in serious distress. These men are being helped by monthly appropriations from the funds of the Engineers Society. There seems to be little prospect of increasing the employment in the near future from industrial sources. However, a considerable amount of municipal and government work is under contemplation, and it is expected that some placements will be possible in this manner. It appears that the depression has in many cases required engineers of a high grade and of good professional standing to take up work in other lines—in many cases with marked success. This may mean a permanent displacement of men of this type into other lines of work."

From the Utah Section: "The membership of this Section numbers about 53. At present it does not seem advisable for it to take up independent relief work. Engineers in this section of the country are individually joining in the general relief movement carried on through cooperation of societies, clubs, and local groups."

### FEWER UNEMPLOYED ENGINEERS LISTED IN COLORADO

From the Denver Section: "The Denver Section, as the other Colorado sections of 4 national engineering societies, has combined its efforts toward relief of unemployed engineers with the Colorado Engineering Council, in the same manner as done last year. Pledges to the Citizens' Unemployment Committee are marked 'For relief of engineers' and funds so derived are made available to the Colorado Engineering Council's relief committee. Approximately 190 engineers and draftsmen are listed with the committee at present. This is less than at the same time last year, although in the late winter the number reached 247 last year, with an increase anticipated this year. Approximately $10,000 was distributed in this way last year. We hope that the funds made available in this campaign will be greater. The men have been employed on engineering work which, if resulting in construction, will produce employment for a large number of men, such as flood control, city drives, and parks. Direction of this work has been done by prominent engineers who have donated their services. Men are paid $3 a day employed, and the work is rotated to distribute the benefits as far as possible."

From the Oklahoma City Section: "We have read of the activities of various Sections in unemployment relief work in the March and November 1932 issues of the ELECTRICAL ENGINEERING and are deeply impressed by the efforts described and would be glad indeed to contribute to the general fund of information had we any experience with the problem. As a matter of fact, the situation in this Section seems not at all comparable to that in the more populous centers. Due, no doubt, to the fact that practically all of our members are in the employ of utility organizations which have followed the policy of apportioning the available work on a reduced time basis, thus avoiding the distress occasioned by dropping men from payrolls. There is not a very large membership in the other engineering societies in this locality and thus far, conditions do not seem to warrant the establishment of any particular program of relief work. This is the consensus of opinion of our executive committee. We believe that, in general, our membership is favorable to still further reductions in individual incomes if necessary to avoid total unemployment. There is, of course, a limit to the extent to which this practise may be carried and it is entirely possible that we may eventually find it necessary to give some special consideration to relief work."

### STATE FUNDS USED IN CHICAGO

From the Chicago Section: "The Chicago Section in cooperation with the other engineering societies is actively working on the following program. State funds have been provided for unemployment relief, part of which are devoted to direct relief such as supplying food and other essentials, and another part to the payment for actual work performed for municipalities and other public bodies. Work of the latter nature has so far been principally confined to common labor, but the engineering societies are now working on 2 specific phases of a program which it is expected will make it possible to care for many, if not all, of the engineers in need of relief during the coming winter. The first phase of the above project consists in finding types of work suitable for engineers, such as making traffic studies, bringing engineering records of the city and other public bodies up to date, all of which cannot be done with the present employed forces. The second phase consists of finding the engineers who are in need of help, making the necessary classification, and seeing that they obtain work of a suitable nature, as outlined above. In addition to the above, certain of the local sections of the engineering societies are making direct loans to needy members, although the extent of this work and the amount of money distributed is relatively small."

**Electragists Revert to Original Name.**—At the annual meeting of the Association of Electragists, International, held in Kansas City, Mo., October 10–12, 1932, it was decided by unanimous vote to change the name of this association to the National Electrical Contractors' Association. This latter name is the one under which it was organized 31 years ago. The trademark "Electragist" will still be used in conjunction with the association name as identification of membership.

**Report on Banking Issued.**—After an exhaustive study of the banking situation by its staff experts, the National Industrial Conference Board, Inc., has issued a report under the title "The Banking Situation in the United States." One of the conclusions reached by this study is that the various measures recently enacted by Congress for the relief of the financial situation in the United States are for the most part temporary expedients and that while some of them may contribute in a certain degree to the permanent improvement of banking conditions, it would be an illusion to conclude that they are capable of providing a lasting solution of the American banking problem. Many aspects of the banking situation are discussed, and the significance of the startling developments in the field of banking that have taken place during the last 2 years are set forth lucidly in this report.

## World's Fair Electrical Group Dedicated

The electrical group of Chicago's 1933 World's Fair—A Century of Progress Exposition—comprising the radio hall, communications hall, and the electrical building, was dedicated on Wednesday, October 12, 1932, under the auspices of the Electric Association of Chicago. B. E. Sunny (A'03, F'13) former president and chairman of the Illinois Bell Telephone Company, and director and member of the executive committee of the General Electric Company delivered the address of dedication. Mr. Sunny is a trustee of the 1933 Exposition and was a director of the World's Columbian Exposition of 1893. W. O. Batchelder (A'08), president of the Electric Association of Chicago, presided at the ceremonies. Rufus C. Dawes, president of a Century of Progress Exposition, spoke on behalf of the fair.

The electrical group is a huge sickle-shaped structure nearly $^1/_4$ mile long which rises on Northerly Island and faces a beautiful lagoon opening into Lake Michigan. A bridge connects it with the Hall of Science which is located opposite on the mainland. The story of the development of electricity for mankind's uses which has occurred in the century which the exposition will celebrate will be unfolded by means of moving, animated exhibits in this group of buildings. Manufacturers of electrical machinery, equipment and supplies, producers of electrical devices of all descriptions, radio manufacturers, and companies providing the nation with telegraph and telephone service have already contracted for extensive blocks of space in the electrical group and are developing their exhibit plans.

**Sale of Electrical Goods in Southwest Analyzed.**—The answer to the question of who gets the consumer's dollar spent for electrical equipment and supplies in the Gulf Southwest hardware trade is one of the interesting sidelights brought out in the Department of Commerce's newest regional commercial study "Hardware Distribution in the Gulf Southwest." This publication offers to interested manufacturers and distributors a thorough study of the wholesale and retail structure of the trade in this territory. Among the findings brought out are that approximately 28 cents of each dollar spent for electric wiring supplies by customers of the hardware trade is retained by the retailer, 14 cents goes to the wholesaler, and the remaining 58 cents goes to the manufacturer. In small electrical applic ances it is revealed that the split-up is 32 cents to the retailer, 12 cents to the wholesaler, and 56 cents to the manufacturer. Other products show different distributions. The average gross profit margin of electrical wiring supplies was found to be 19 per cent; small electrical appliances, 18 per cent; mechanical refrigerators, 33 per cent; radios, 22 per cent; and vacuum cleaners, 21 per cent. Copies of the report may be obtained at 40 cents each from the Superintendent of Documents, Government Printing Office, Washington, D. C., or from district offices of the Bureau of Foreign and Domestic Commerce in principal cities of the country.

## Volume Issued on Geophysical Prospecting

"Geophysical prospecting methods are, in final analysis, simply means of geological surveying. Almost every variation in physical properties of rocks, minerals, and ground waters gives rise to anomalies which under favorable conditions might be measured and used to trace formations, contacts, and structures...." This statement is contained in the foreward of "Geophysical Prospecting, 1932," a new volume on a new science, published by the American Institute of Mining & Metallurgical Engineers. The cloth bound volume can be secured from this organization at 29 West 39th Street, New York, N. Y., at a cost of $5 postpaid in the United States.

The contents of this work include: 2 papers evaluating the geological utility of various geophysical methods; 4 papers containing descriptions of the application of electrical geophysical technique to the study of geological problems of a type to interest civil engineers; 2 papers describing the use of magnetic methods for investigating subsurface conditions; a discussion of the effect of moisture in rocks and soils on their electrical conductivities; a description of the construction and uses of geophones; and numerous other papers dealing with special phases of electrical, magnetic, seismic, and gravitational methods in geophysical exploration.

**Power Use on Farms Increasing.**—An analysis of the use of power machinery on the farm is presented in a recent issue of the bulletin of the National Industrial Conference Board, Inc., New York, N. Y., which states that the hand methods formerly in use required about 60 hr of labor for one man to harvest and thresh an acre of wheat, whereas with the self-binder and stationary threshing machine, the time was cut to from 4.5 to 8 manhours, and with the coming of the "combine," the manhours were reduced to from $1/2$ hr to $1^1/2$ hr. The gain in efficiency per worker achieved by these mechanical aids is from 4,000 to 12,000 per cent, with a consequent labor displacement of 97.5 to 99.2 per cent. These figures are based upon the records of the principal wheat growing states of this country, the greatest gain in efficiency being noted in California. The continuance of this trend is pointed out in the bulletin, indicating the possible elimination at some future time of wheat farming where such machinery is not used. Although tractive power represents the chief use of mechanical power in farming operations, there has been a considerable use of electricity in farming where central power stations are accessible.

**Accidents Reduced by Highway Lighting.**—During the past 18 months, 2 main highways in Schenectady County, New York State, have been illuminated at night by highway luminaires. During this period the 2 highways have had 42.3 per cent fewer night accidents than during the preceding 18 months, and 21.2 per cent fewer day accidents. The emphatic reduction in night accidents, which is double the improvement in day accidents, doubtless is due to the installation of highway lighting, as other road conditions have remained unchanged.

## Hoover Dam Cableways Ordered

In connection with the construction work at Hoover Dam, the Six Companies, Inc., recently awarded contracts for 5 20-ton cableways. These cableways will be used to raise excavated material from the canyon, place concrete in the dam, and handle equipment and materials. Two cableways with moving towers running on tracks benched on both the Nevada and Arizona sides, with spans of 2,580 ft each, will serve the spillway area. The dam site will be covered by 2 cableways of similar type, but with spans of 1,380 ft each. The fifth cableway will be of the radial type, with a 1,365 ft span, and will cover the lower portals of the spillway and penstock tunnels.

Six contracts have been awarded for the various parts of this equipment. The motors and control equipments are now being shipped from the East Pittsburgh works of the Westinghouse Electric and Manufacturing Company and include 5 500-hp 585-rpm main hoist and trolley motors for the 5 20-ton cableways, 9 motors ranging in size from 75 to 150 hp for moving the cable towers sideways, and 33 control boards. All motors are of the wound rotor type, operating from 2,300-volt 3-phase 60-cycle power, and equipped with full magnetic reversing plugging control.

**Manual on Endurance of Metals Available.**—In 1927 the Engineering Foundation published a "Manual of the Endurance of Metals under Repeated Stress" in which the views and data upon the fatigue of metals were summarized for designers, inspectors, and testing engineers. The Engineering Societies Library, 29 West 39th Street, New York, N. Y., has acquired the remaining stock of this work and will be glad to send a copy to any one interested, upon receipt of 25 cents to cover shipping costs.

## Montefiore Award for 1932 Announced

The George Montefiore Prize, which is awarded triennially for articles published during the 3 years preceding the award, has been determined for this year by the jury which met at Liege, Belgium, October 1 and 2, 1932. The prize, which this year amounted to 21,500 fr., has been divided. Three articles were chosen: these are by L. Barbillion, engineer, professor at the University of Grenoble; A. Guilbert, Doctor of Sciences, engineer in Paris, and C. J. van Griethuysen, engineer at Marcinelle. ELECTRICAL ENGINEERING for February 1932, p. 135 carried an announcement of this award, inviting the submission of articles to the jury.

The award is for the best original works contributing to the scientific or technical advancement of electricity. The authors may be from any country. The prize is administered through the Association des Ingenieurs Electriciens, or a national electrical society of Belgium. This association is an outgrowth of the Institut Electrotechnique Montefiore, which is attached to the University of Liege.

The jury, under the direction of Omer De Bast, director of the Institut Electrotechnique Montefiore, is composed of 10 electrical engineers who are well known in the electrical industry in Belgium and other countries, and includes as a member A. E. Blondell (A'05, HM'12), professor at the École National des Ponts et Chaussees of Paris. The next meeting will be held in 1935 at which a prize of 22,000 fr. will be given.

**Chromium Plating Patent of Doctor Fink Upheld.**—Validity of the patent of Dr. C. G. Fink, professor of electrochemistry at Columbia University, New York, N. Y., covering commercial chromium plating, was sustained by an unanimous decision of the U.S. Circuit Court of Appeals for the second circuit, in which all claims of the inventor to his basic methods for chromium plating were upheld. The suit was brought by United Chromium, Inc., holder of Doctor Fink's patent, against the International Silver Company, which based its defense upon the research performed by the U.S. Bureau of Standards, the Eastman Kodak Company, and the Westinghouse Electric Manufacturing Company. The Court of Appeals held that this work failed to anticipate the work of Doctor Fink, and that the patent provided the method with which "for the first time the art could turn out chromium plating with certainty." The work of Doctor Fink was revealed as one of the great achievements of modern chemical research. For many years chemists attempted to solve the problem of plating metals with chromium, but without success. Doctor Fink worked at the problem, and after making numerous experiments he finally evolved a basic method to plate objects with a uniform and adherent coating of chromium. He found that the chromium particles could be deposited successfully in a durable coating only in the presence of a catalytic agent in the plating bath. Proper concentration of this catalyst in the plating bath eliminates erratic and uncertain results in chromium plating.

## Electrical Engineers Increase in Number

A comparison of 1920 and 1930 census figures gives a vivid picture of changes that have been taking place in occupational distribution. This data which can be obtained from the Superintendent of Documents, Washington, D. C., for all occupations and sections of the country, has been summarized in a recent bulletin of the Personnel Research Federation, 29 West 39th St., New York, N. Y. The following paragraph is taken from this bulletin:

"It seems that many more men have been entering professional careers. Only in the profession of veterinary surgery was there a substantial decline. The supply of male dentists increased a trifle faster than the total working population, and of physicians and surgeons a little more slowly; but the number of women in these professions definitely decreased. Most spectacular of all, there were more than twice as many electrical engineers in 1930 as in 1920. Stock brokers and insurance agents also more than doubled in number. The transfer of functions from home to shop is reflected in the data regarding men and women workers in cleaning, dyeing, and pressing establishments. The 1930 figures are 389 per cent and 473 per cent, respectively, of those from 1920."

The data given in Table I summarized the changes in the engineering profession over this 10-year period. In addition to the males shown in this table, there were in all occupations in the United States 10,752,116 females, 127 per cent of the number employed in 1920.

Table I—Comparison of 1920 and 1930 Census Figures for Engineers

| | U. S. A.—Male | | N. Y. C.—Male | |
|---|---|---|---|---|
| | 1930 | % of 1920 | 1930 | % of 1920 |
| All occupations | 38,077,804 | 115 | 2,324,599 | 126 |
| Civil engineers and surveyors | 102,057 | 158 | 6,782 | 141 |
| Designers, draftsmen, and inventors | 93,518 | 149 | | |
| Electrical engineers | 57,775 | 214 | 5,475 | 223 |
| Mechanical engineers | 54,338 | 141 | 4,120 | 121 |

# Letters to the Editor

CONTRIBUTIONS to these columns are invited from Institute members and subscribers. They should be concise and may deal with technical papers, articles published in previous issues, or other subjects of some general interest and professional importance. ELECTRICAL ENGINEERING will endeavor to publish as many letters as possible, but of necessity reserves the right to publish them in whole or in part, or to reject them entirely. STATEMENTS in these letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the American Institute of Electrical Engineers.

## Rudolph Frederick Schuchardt —An Appreciation

*To the Editor:*

On October 25, 1932, there passed from among us one of God's noblemen, Rudolph Frederick Schuchardt, a past-president of the American Institute of Electrical Engineers, and chief electrical engineer of the Commonwealth Edison Company.

Modest, courteous, lovable, a clear thinker, an able organizer and executive, Mr. Schuchardt, in spite of his multitudinous duties and responsibilities was never too busy to help a friend or serve his fellow man.

For the past 10 years, his life was permeated with ill health and saddened by the tragic loss of his beloved wife, but he refused to be crushed by fate and during this period, faithful to his high ideals, rendered conspicuous service. Engraved upon his heart was the gallant motto, "Ich dien."

Honored by his friendship for a quarter of a century, I wish to add my tribute to the memory of so fine a gentleman, so lovable a friend.

Very truly yours,
H. L. WALLAU (A'00, F'13)
(Chief Electrical Engineer,
Cleveland Electric Illuminating Co., Cleveland, O.)

## Brass Tacks in Economics

*To the Editor:*

The article under the title "Brass Tacks in Economics" by David Cushman Coyle in ELECTRICAL ENGINEERING for October 1932, p. 712–3, is one of the most suggestive yet printed in the symposium "Has Man Benefited by Engineering Progress?" In a few words it points out the principal problems still to be solved by our Western civilization.

Unless some such solution is seriously undertaken during this generation or the next, it is most probable that some form of socialism or communism will be adopted by most Western nations or by a league of all the nations which are predominantly Caucasian.

If the present Russian experiment proves successful within the next few decades, then a league of this kind will probably be formed at a much earlier date. Once the masses of the Western nations realize that the masses of Russia have reached a standard of living equal to or approaching theirs, without the savage competitive system of the capitalistic world, it would be easy for the leaders of the movement to obtain sufficient following for the establishment of a similar system, either by peaceful and legal methods or by revolution. If the 200,000,000 Russians are living happily without unemployment or idleness, with ample time for recreation and with all the luxuries which we Westerners consider necessities, if they have no arrogant multi-millionaires, no powerful captains of industry, no ruthless commercial warfare, no crowding of the weak by the strong, it will not be difficult for the Western people to realize that there is a new theory of political economy which may be nearer the ideal state than that under which they live.

It seems to me, however, that to carry out Mr. Coyle's suggestion it would be necessary to overcome 3 almost insurmountable obstacles. The first of these is the usual inefficiency and the frequent corruption of most government channels. If heavy taxes on large incomes are collected and the proceeds spent in public and semi-public construction, the collection and the expenditures must be in the hands of a political bureaucracy. Can we depend on the incorruptibility of the members of this bureaucracy and on the ability with which their work will be performed? In view of the corruption and inefficiency so frequently found in our national, state, and municipal administrations, is it possible for any thoughtful man to believe that with our present methods of electing our representatives, our officials, and our judges, these taxes will be collected fairly and economically and spent efficiently and honestly? The first step, then, must be the improvement of the morals of our officials, and as their morality is but a reflection of the morality of the citizens, we must begin by improving the morality of the citizenship. This lack of morality is probably due to the complete breakdown of our religious systems which are the foundations of our morality. If all that the citizens do toward living a better life is to give lip service to their religious leaders on Sunday and act so as to keep just within the law on other days, then little can be expected of real human progress. It would seem, therefore, that the first step required to insure the success of the proposed plan would be to develop a high sense of moral integrity in the citizenry and that little can be gained until that is done.

The second problem which seems difficult to solve is how to give a suitable incentive to inventors and promoters, and how to obtain the advantages of quantity production, of large research and development laboratories. If we had had no large accumulations of capital or rather if the inventors, promoters, and financiers had not seen the possibilities of obtaining great wealth and power, we probably would not have been able to obtain many of the benefits of the present machine age. These inventions may not have served to develop greatly the spiritual aspirations of the human soul but the railroad, the telegraph, and telephone, the dynamo and the internal combustion engine, the aeroplane, the cinema and the radio, have done much to change our world and this scientific and mechanical progress has undoubtedly had considerable effect in the elevation of the human spirit. But many of these things would not have been possible without capital and without the spur of the possible wealth, glory, and power to be attained if successful. Similarly, untold wealth has been lost in trying to develop inventions which have proved unsuccessful, and for that reason it would seem that substantial rewards should be permissible for the adventurers in the fields of science and invention.

The third problem is the necessity of having a union or league of all Caucasian nations before any such system can be put in effect, because no plan of this nature could be successful unless it could be carried out simultaneously in the other nations with which we have to live in this small planet, or at least in a substantial part of the nations which are generally included in our European civilization. As a matter of fact, all the peoples of the world should form part of this federation, but probably the experiment could be properly tried with fair chance of success if, at first, all the basically Caucasian nations would join in it, leaving to the others the opportunity of joining it later. Without practically universal acceptance, the interference from the outside, where institutions of the purely capitalistic, competitive type still ruled, would make the plan unworkable.

Very truly yours,
GUSTAVO LOBO (A'01, F'12)
(President and Treasurer,
Kelvin Engg. Co., Inc.,
New York, N. Y.)

## Too Much Investment Money!

*To the Editor:*

In the October 1932 issue of ELECTRICAL ENGINEERING, p. 712–3, David Cushman Coyle makes the direct statement that there is too much investment money. His whole article, "Brass Tacks in Economics" seems to be based on that statement, and yet he makes no attempt to support it with evidence. We have repeatedly heard the same claim before, but no attempt is ever made to prove it. This is particularly surprising to any one who has had experience in trying to sell equipment. Everywhere we meet the same statement from purchasers, that capital is not available.

If there were too much investment money we should expect that it would appear as a demand for investment securities such as high grade bonds. An excess of investment money must result in a low rate of interest on investment securities, and if the rates are compared for a period of years, we find 6 times this century when these rates dropped decidedly. These years were 1905, 1909, 1916, 1922, 1927, and 1930. If this excess of investment money caused poor business, we should expect that each of these times depression would have followed. Instead every time at least a year of good business followed, with the exception of 1930 in which case it is easy to find reasons why it did not.

Now if we turn to the peaks of interest rates on investment money, which came in the years 1903, 1907, 1913, 1915, 1918, 1920, 1923, 1929, and 1932, we find only one case, the war year 1915, in which the business was good for the following year.

There is other evidence to show that there has never been an excess of investment money in this country, but this simple comparison of the interest rates with business conditions should be enough to demonstrate that the cause of our present troubles is not a surplus of investment money. Some people have been deceived by the low rates of interest of bank loans. These low rates are never given on investment money, but on temporary reserves, on money which may be temporarily loaned on the most liquid securities, but which the holder does not desire or does not dare to invest.

Others have been deceived by the large amounts of wasted capital into thinking that there has been too much. It is not difficult to find cases of poor families spending on some useless luxury the money which they needed for food. We may think that a person who would buy a radio must have an ample surplus, but we know that often that is not the case. And in investments, money has been spent in overexpansion in times when others had difficulty in securing money for needed developments. When a speculative mania is under way, people will throw away what they need, and investors are no different in this respect from the ignorant.

1929 was a year of wasted capital from every side. Gambling profits was consumed in luxuries. The public mortgaged their future for immediate consumption. And perfectly useless business expansion took place. Each caused a loss of investment money, and we are still suffering from that loss. No business revival can take place until a larger proportion of earnings are turned into investments.

Very truly yours,
A. W. FORBES (A'12)
(Forbes & Myers,
Worcester, Mass.)

## Consumption, Production, Distribution

*To the Editor:*

The report of the American Engineering Council committee on "The Relation of Consumption, Production, Distribution" (see ELECTRICAL ENGINEERING for June 1932, p. 373–7) fits so many of the facts that it must contain a very large element of truth. With relatively no foreign capital, funds were available for so much plant expansion from 1923 to 1929 that many engineers and economists regarded our industrial plants as generally overexpanded while during the same period enormous sums were also used to finance the purchase of our products and for speculation.

Simple theories usually require modifications, however. Further study may show that a defective mechanism for controlling the rate and use of savings was the underlying cause of the depression. According to the classical theory of diminishing returns, the excessive diversion of purchasing power to capital uses is controlled by the diminishing returns on additional increments of capital. Why has this mechanism of diminishing returns failed to prevent excessive savings? May I suggest 4 reasons.

1. It requires time to accumulate and invest savings, more time for the invested savings to be converted into new plants, and a further period of operating the new plants before income reports can reflect a diminishing return. There is evidently a lag in the operation of the mechanism of diminishing returns which may easily amount to more than a year.

2. For concerns which are showing a consistent profit the diminishing returns on capital are reflected in a rising market price for their stocks and bonds. This appreciation of the market value of the principal is a more powerful stimulus to savings than any normal interest return.

3. The rising market values of stocks, bonds, and real estate brings a demand from speculators for the use of savings, at rates which do not reflect diminishing returns.

4. An important fraction of the total savings is used to finance purchases of our products. This use includes nearly all foreign loans, the financing of installment selling, and many other extensions of credit.

These are some of the reasons why diminishing returns do not bring about a prompt and effective regulation of savings to the need for new capital. In consequence strains are built up in the economic system until a break occurs and apparently in 1929 all the above methods of investing savings ceased to attract investors within a period of a few weeks. The flow of savings into these types of investment does not, of course, prove that the same volume of savings could not have been safely absorbed had these savings been invested in more conservative low yield engineering works.

In 3 ways this train of events might have been interrupted.

1. If there had been less savings excessive investment in foreign loans, installment financing, and speculation might have been avoided.

2. If investors had deliberately passed by the greater yield of these forms of investments and used their money to finance self-liquidating projects at a smaller yield there would have been no economic strains and no collapse of our investment machinery.

3. If when the collapse came, every one, including corporations, had immediately changed his saving habits and spent, or given away to be immediately spent, the part of his income which he had been saving, we should have had only a readjustment between different industries and not a semi-paralysis of all industry.

That any of these things should happen as the result of enlightenment or exhortation is too much to expect of human nature. Some form of regulation, probably through shifting the tax load on to the uneconomic forms of investment when these threaten to become excessive, must be developed.

Very truly yours,
F. C. BRECKENRIDGE
(Washington, D. C.)

## What About the Engineer?

*To the Editor:*

In the *Saturday Evening Post* for November 5, 1932, Frank A. Vanderlip, former president of the National City Bank, propounds the question "What about the banks?" and dissertates upon the query with comprehensive scope in his 7,000 word but terse article.

In order to avoid further governmental regulation of our banks, Mr. Vanderlip outlines necessary changes in present practise which the banking fraternity should initiate and adopt. His article culminates in the practical suggestion that the Clearing House Committee, the Federal Reserve Bank, and the New York Stock Exchange jointly prepare a questionnaire that must be answered before any new security issue may be floated in the New York market provided the houses of issue would be amenable to the plan.

At this juncture he suggests a subsequent check by engineers to certify that money obtained for construction purposes had actually been devoted properly to such construction and what commissions or bonuses, if any, were paid. This coming from such high banking authority as F. A.

Vanderlip is a tribute to the engineer for his utility in our society beyond the scope of mere technical production.

We know that we have sometimes seen on bond circulars testimony by engineering firms as to the accuracy of statements concerning plant and property. But, as Mr. Vanderlip implies, they are far too few and these often more of form than of complete fact.

If that practise is to be effective, is to be real, the bank will need to have its own engineer whose work must prove its worth over a period of years. He will need to do more than merely report that so much money has been spent for so much construction of plant. As time goes on methods change, depreciation and obsolescence enter the scene and in the case of many enterprises the more time that elapses the more difficult it becomes to keep a clear distinction between accounted capital and effective capital. While ordinary accounting practise is an accurate procedure, management judgment over a period of years in the handling of a multitude of items in transition from earnings to profit and loss surplus and thus to effective capital, may effect material changes in effective capital and hence earning power. The proper expenditure of a given sum adds that sum to accounted capital but it may add more or less than a given sum to the effective capital, particularly over a period of time. This determination is also proper work for the engineer.

It is the banker's prerogative to make the financial decision as to earning capacity behind any specific bond issue but such decision is arrived at after careful consideration and evaluation of the contributory technical facts furnished by the engineer and by the accountant.

It is to be hoped that the engineering profession will serve to take its part in such a constructive program which will at least help to minimize the bad effects of such a financial debacle as we recently experienced.

Very truly yours,
**Frank C. Czarnecki** (A'15)
(37 West 39th St., New York, N. Y.)

## Method for Fitting a Straight Line to Plotted Points

*To the Editor:*

At times it is desirable to draw a straight line through a number of plotted points and to find the equation of the line which best represents the points. There are various methods employed, such as stretching a string and drawing a line by inspection, the method of averages, and the method of least squares which gives the "best" line.

The method of drawing the line by inspection, and the method of averages, while quite simple and requiring little computation, have the disadvantage of giving inconsistent results; that is, the position of the line is influenced by the judgment of the person drawing it and therefore 2 people might not arrive at the same line from a given set of data.

The method of least squares is admittedly the best method and gives consistent results, but the computations become quite laborious when there is a large number of points.

The following method removes the inconsistencies due to the personal judgment of the computer and involves less labor in computing than the method of least squares. It is believed to be satisfactory for most engineering purposes except where a degree of precision is required which justifies the use of least squares and the lengthier computations involved.

Let $(x_1, y_1), (x_2, y_2), \ldots (x_n, y_n)$ be a series of observed points through which it is desired to draw the straight line of closest fit. Let it also be assumed that the required line will pass through a point whose ordinate is the average of all the observed values of $y$, and whose abscissa is the average of all the observed values of $x$, that is, one point on the line is $(x_a, y_a)$ where $x_a$ equals $\frac{\Sigma x}{n}$ and $y_a$ equals $\frac{\Sigma y}{n}$.

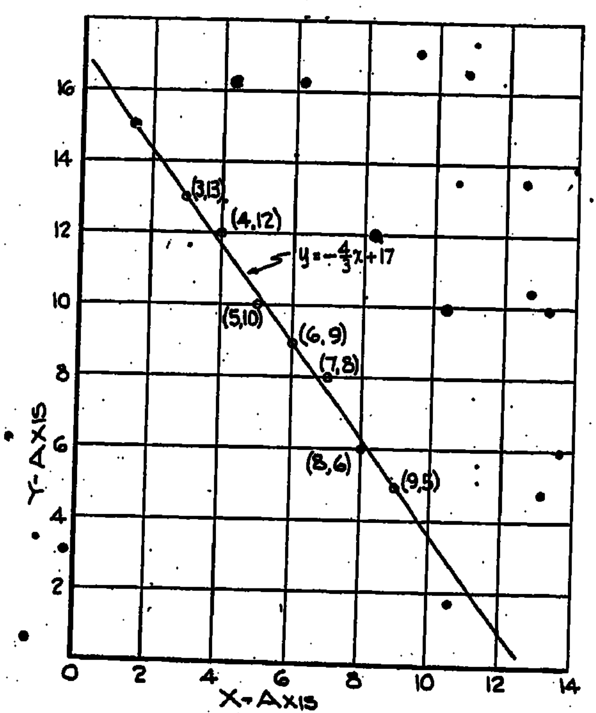

Fig. 1

If the point $(x_a, y_a)$ is now considered as the center of coordinates, the line will have an equation of the form

$$y' = mx'$$

and the coordinates of the points $(x_1, y_1)$, $(x_2, y_2)$, etc., in the original data will be the deviations of the observed points from $(x_a, y_a)$. The straight line will now pass through the new origin, $(x_a, y_a)$, and lie in the first and third, or in the second and fourth, quadrants.

Inasmuch as the line is straight and passes through the new origin, all the points can be placed in one quadrant by giving them the same relative location in that quadrant as they had in the quadrant from which they were removed. This is the same as considering all the deviations as having the same sign. By averaging all the absolute values of the $x$ deviations and all the values of the $y$ deviations, the point $(x_b, y_b)$ is obtained, where $x_b = \frac{\Sigma|d_x|}{n}$ and $y_b = \frac{\Sigma|d_y|}{n}$; $\Sigma|d_x|$ and $\Sigma|d_y|$ being the sum of the absolute values of $(x_1 - x_a)$, $(x_2 - x_a)$, etc., and $(y_1 - y_a)$, $(y_2 - y_a)$, etc., respectively.

The equation of the line passing through the origin $(x_a, y_a)$ and the point $(x_b, y_b)$ is

$$y' = \frac{y_b}{x_b} x'$$

$$= \frac{\frac{\Sigma|d_y|}{n}}{\frac{\Sigma|d_x|}{n}} x' = \frac{\Sigma|d_y|}{\Sigma|d_x|} x'$$

where $\frac{\Sigma|d_y|}{\Sigma|d_x|}$ is the slope.

If the line is now referred to the point $(0, 0)$ as the origin instead of $(x_a, y_a)$, its equation becomes

$$y - y_a = \frac{\Sigma|d_y|}{\Sigma|d_x|}(x - x_a)$$

$$y = \frac{\Sigma|d_y|}{\Sigma|d_x|} x + \frac{\Sigma y}{n} - \frac{\Sigma|d_y|}{\Sigma|d_x|} \frac{\Sigma x}{n}$$

the slope being $\frac{\Sigma|d_y|}{\Sigma|d_x|}$ and the $y$ intercept being $\frac{\Sigma y}{n} - \frac{\Sigma|d_y|}{\Sigma|d_x|} \frac{\Sigma x}{n}$.

The sign of $\frac{\Sigma|d_y|}{\Sigma|d_x|}$ is determined by noting the signs of the deviations. If it is found that the $x$ deviations and their corresponding $y$ deviations have like signs the slope of the line is positive and $\frac{\Sigma|d_y|}{\Sigma|d_x|}$ is plus; if the signs are unlike the slope of the line is negative and the minus sign is used with $\frac{\Sigma|d_y|}{\Sigma|d_x|}$.

The following example, illustrated in Fig. 1, is worked out in detail to show the method.

| $x$ | $x_a$ | $d_x$ |
|---|---|---|
| 3 | − 6 | −3 |
| 4 | − 6 | −2 |
| 5 | − 6 | −1 |
| 6 | − 6 | 0 |
| 7 | − 6 | +1 |
| 8 | − 6 | +2 |
| 9 | − 6 | +3 |
| $\Sigma x = 42$ | | $\Sigma\|d_x\| = 12$ |

| $y$ | $y_a$ | $d_y$ |
|---|---|---|
| 13 | − 9 | +4 |
| 12 | − 9 | +3 |
| 10 | − 9 | +1 |
| 9 | − 9 | 0 |
| 8 | − 9 | −1 |
| 6 | − 9 | −3 |
| 5 | − 9 | −4 |
| $\Sigma y = 63$ | | $\Sigma\|d_y\| = 16$ |

$$x_a = \frac{42}{7} = 6 \qquad y_a = \frac{63}{7} = 9$$

The slope of the line is

$$-\frac{16}{12} = -\frac{4}{3} = -1.333$$

It is given the negative sign because the corresponding values of $d_x$ and $d_y$ are unlike. The $y$ intercept is

$$9 - \left(-\frac{4}{3}\right) 6 = 9 + 8 = 17.$$

and the required equation is

$$y = -\frac{4}{3}x + 17$$

The least squares line has been worked out and is

$$y = -1.35x + 17.1,$$

showing that the method described agrees quite closely with the least squares "best" line and is satisfactory for a great many applications.

Very truly yours,
**Hector B. Samson** (A'27)
(1729 Madison Ave.,
Dunmore, Pa.)

## Graphical Determination of the Symmetrical Components in a 3-Phase Unbalanced System

*To the Editor:*

An unbalanced 3-phase system may be resolved into 3 sets of symmetrical components which are: 2 balanced 3-phase systems of opposite rotation and a uniphase component. When great accuracy is needed, these components are analytically determined with 3 equations, following a method developed by C. L. Fortescue.

As far as I know, the graphical solutions that have been suggested make use of a

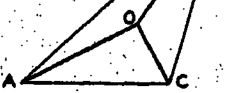

Fig. 1

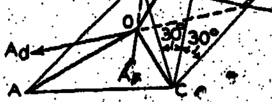

Fig. 2

ferent geometrical construction to deter- ne each one of the components. In this ter, I would suggest a general solution it can be performed on a single diagram. We shall first consider the case when there no residual component; afterward it l be shown that the solution equally plies when the sum of the 3 vectors is : zero.

### RESIDUAL COMPONENT

Let us take the 3 unbalanced vectors ., $OB$, and $OC$ whose sum is zero (Fig. 1). Join the points $ABC$ of the vectors by aight lines, thus making a triangle g. 1).

Through the middle point of the side ', draw a line $XY$ perpendicular to $BC$ g. 2). From the corner $C$, draw 2 aight lines, respectively, making a 30° gle on each side of $BC$; these 2 lines ersect the perpendicular $XY$ at $A'_r$ and ι. Joining $A'_r$ and $A'_d$ to the neutral we get the lines $OA'_r$ and $OA'_d$.

$)A'_r$ is equal in magnitude to the reverse ıse component of $OA$; this line $OA'_r$ ıuld be prolonged past $O$ to obtain the ıt vectorial position, which is 180° m $OA'_r$, to a point $A_r$ equally distant n $O$ as $A'_r$.

Similarly $OA'_d$ is equal to the direct ıse component and 180° out of phase;

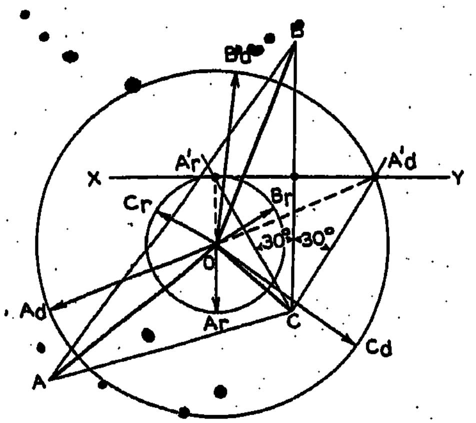

Fig. 3

long this vector through $O$ by an equal gth in the opposite direction.

Now that we know the components of in each symmetrical system, it is easy find out the components of the other ıses because they are symmetrical and ° apart from each other. The solution nade easier if we draw 2 circles with $O$ center and $OA'_r$ and $OA'_d$ as radii g. 3).

Any side of the triangle may be used to ermine the initial components, the side en always giving the components of the osite phase: *e. g.*, side $BC$ giving components of $OA$, side $AB$ giving components $)C$ and side $CA$ giving components of $OB$.

### NERAL SOLUTION

The method usually followed when there ı uniphase component is to add the 3 tors and find out their sum; the sum is al in magnitude and direction, to 3 es the uniphase component. After- 'd this component is subtracted from h vector and with these new vectors we ıe back to the problem as explained ve.

However, it can be noted that when the phase component has been subtracted n each vector (Fig. 4), the new enclosing ngle $A'B'C'$ is equal to the original ngle $ABC$.

Also the distance between the origin of vectors $O$ and the center of gravity $O'$ the triangle $ABC$ (Fig. 5), is equal in magnitude and direction to the uniphase component.

From the above considerations we can draw 3 conclusions:

1. **When there is a residual component the enclosing triangle can still be used for the solution.**
2. **Joining the extremities $A$, $B$, and $C$ of the vectors to the triangle center of gravity is equivalent to subtracting the uniphase component from each vector.**
3. **The triangle center of gravity, and not the neutral point, should be used for finding the symmetrical components. (When there is no uniphase component, the neutral point and the center of gravity coincide.)**

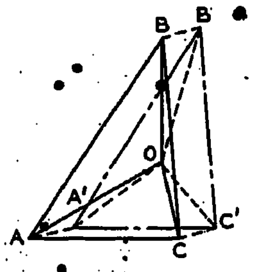

Fig. 4

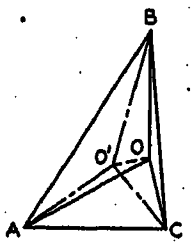

Fig. 5

### PROCEDURE

The following procedure is suggested for a general graphical solution (Fig. 6):

1. **Draw a triangle around the 3 unbalanced vectors $OA$, $OB$, and $OC$ as previously described.**
2. **Locate the triangle center of gravity, $O'$ (in a triangle, the center of gravity is at the intersection of the 3 lines joining each corner to the middle of the opposite side; it is always located at $^1/_3$ of the height).**
3. **Erect a perpendicular $XY$ to the side $BC$ through its middle point.**
4. **From the corner $B$, draw 2 lines, respectively, making a 30° angle on each side of $BC$; these 2 lines intersect the perpendicular $XY$ at $A'_d$ and $A'_r$.**
5. **Draw 3 circles with $O'$ (center of gravity) as common center and, respectively, passing through the points $O$, $A'_d$, and $A'_r$.**
6. **Prolong the lines $O'O$, $O'A'_d$, and $O'A'_r$ through $O'$ to the opposite side of their respective circles.**

We now have the 3 components for the vector $OA$. The direct and reverse sequence components for the other vectors $OB$ and $OC$ are 120° apart from the components of $OA$; the uniphase component is the same for the 3 vectors.

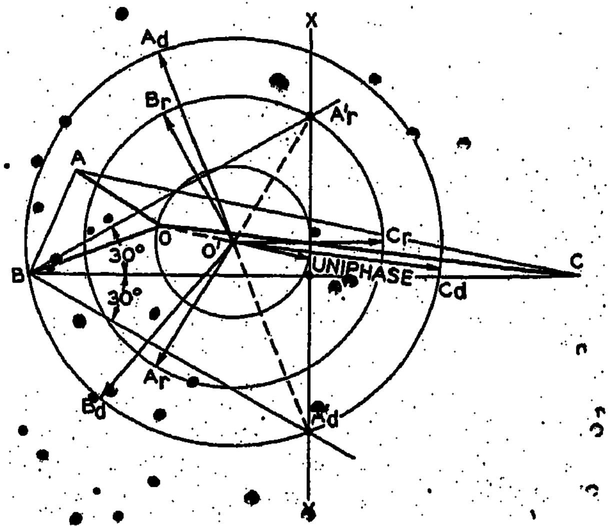

Fig. 6

Apart from its completeness, this method would be very convenient for a quick estimate of the unbalance factor.

Very truly yours,
R. LAPLANTE (A'32)
(Shawinigan Water & Power Co.,
Shawinigan Falls, Quebec, Can.)

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## Young Engineers Must Plan for the Future

*To the Editor:*

The "Letter to the Editor" from Dr. Valdimir Karapetoff published in the September 1932 issue of ELECTRICAL ENGINEERING, p. 669, proposes a fundamental change in educational methods in the United States that would be of great value to the engineering profession as a whole, were it put into practise generally. Briefly, it consists of training the engineering student along such lines that in this rapidly advancing profession he will be capable of doing modern engineering work soon after graduation, without the necessity of first going through various training and test jobs to find out what the engineering profession has been doing in the 10 years since his textbooks were written, and what it is going to do in the next 10 years. The chief advantage of such an educational method lies in the hope that an engineer trained in college to look beyond present achievements may perchance carry the habit with him into professional life.

Two years ago I listened to Dr. Karapetoff talk to a small group of prominent physicists and 2 engineers about the need for applied scientists and theoretical engineers to act as intermediaries between mathematical physicists and practising engineers. As a very pertinent example of a problem badly in need of such treatment, Dr. Karapetoff mentioned very briefly the polymerization of insulating materials in high voltage cables. In the discussion that followed, the subject of Dr. Karapetoff's talk and the purpose of his visit were completely forgotten in the advancing of hair-trigger theories about polymerization; the 2 engineers were visitors and so listened and went away without learning how to better effect an interchange of knowledge and experience with their physicist acquaintances.

It is rather apparent that any constructive action in this direction must start from the engineers' side of the fence; later perhaps, the theoretical physicists may change their attitude sufficiently to welcome with more open arms the advances of men who are motivated solely by a sincere wish to further scientific knowledge and technical achievement. For the present it seems that with a few notable exceptions, physicists do not care to extend their activities toward engineering fields, and indeed do not care to offer instruction to those who seriously contemplate applied physics and theoretical engineering.

In the research laboratories of our large electrical industries there may be found the applied scientists and theoretical engineers necessary to the rapid advance of industrial art. The small organizations are indeed fortunate to have at their call the services of such individuals. The training facilities of these research laboratories are much too restricted to supply the needs of the engineering profession in the future for scientifically trained men, and it remains for the colleges and universities to take over a large part of the burden.

The 4-year college course has in the past been the greatest stumbling block to engineering training. To get something more than a trade school education in 4 years of college and not at the same time neglect the technical courses, is at present well-nigh impossible. Formerly a student could neglect to a great extent the technical side of his college education for the cultural side, taking up the technical features as needed after graduation. Now such a very great deal is expected of the engineering graduate that that course is no longer possible; and indeed, after a rigorous 4-year college course leading to a degree in engineering, most graduates still need much further engineering study, not to mention cultural studies. Some get advanced work in post-graduate courses, others in apprentice jobs, and many more neglect it entirely and drift to other fields of endeavor.

Perhaps the solution is a 5 or 6-year course, leading to a master of engineering degree, with the last 2 years patterned more after the English plan of independent work and personal supervision by a faculty member, but there again rises the necessity of many promising students to abandon study after 4 years to enter wage-earning fields. Some solution can and should be worked out; for without more time, it is impossible without neglecting other necessities, to do more than mention the things Dr. Karapetoff speaks of so earnestly.

Very truly yours,
**Frank W. Godsby** (A'30)
(Development Engineer, The Safety Car Heating and Lighting Co., New Haven, Conn.)

## Reactive Volt-Amperes

*To the Editor:*

The lines in the usual diagrams illustrating power factor correction are vectors of volts and amperes although they may be labelled (convenience excusing such labelling) kilowatts and reactive volt-amperes.

A-c volt-amperes, whether watt or wattless, are not vector quantities, and they cannot be represented by vectors. It is only by a confusion of ideas that the operator $j$ is applied to watts or to volt-amperes.

In the useful pamphlets (GET-191A and GEA-1508), recently published by the General Electric Company, the current vectors labelled "leading reactive kva" are shown lagging instead of leading, and lagging vectors are shown leading. Also we find the queerly muddled sentence: "This 'wattless' current or rkva may lag behind the voltage wave."

I suggest that the common practise of using the mongrel term "reactive power" be given up in favor of "reactive volt-amperes"; that the practise be adopted of stating plainly that the vectors labelled power and volt-amperes in power factor correction diagrams are vectors of volts or of amperes, as the case may be, and that, in such diagrams the convention common to other vector diagrams be followed of measuring angles of lead counter-clockwise.

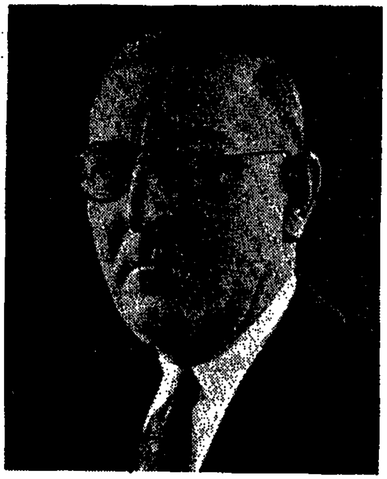
Very truly yours,
**F. M. Denton** (A'08, F'28)
(Head of Electrical Engg. Dept., University of New Mexico, Albuquerque)

## Karl S. Wagner Sought by Legation

Institute headquarters has been advised by the Roumanian Legation at Washington, D. C., that the "legation has very important information of a personal character and interest" for one Karl S. Wagner, whom the legation describes as an American engineer having traveled in Russia in 1913 in the employ of a New York company. Some time later he is reported to have moved to Michigan.

Members knowing the whereabouts of Engineer Wagner may do him a personal favor of some importance by conveying this information to him, that he may act accordingly.

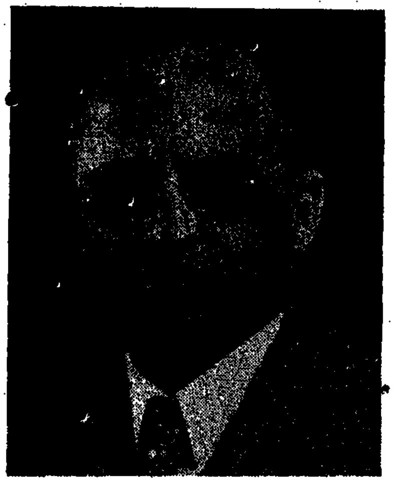
# Personal



W. T. BLACKWELL

**W. T. Blackwell** (A'22) general lighting representative of the Public Service Electric and Gas Company, Newark, N. J., has received reelection for the current year to the chairmanship of the Institute's technical committee on the production and application of light. Mr. Blackwell's early education consisted of private tutelage and preparatory school. In 1897 at the age of 18 he entered the construction department of the New York Telephone Company, New York, N. Y., remaining there until in 1902 when he became engineer in charge of street construction for the East River Gas Company, Long Island City. Mr. Blackwell has been associated with the lighting industry since 1905; in that year he was appointed assistant to the chief engineer of light and power, department of water supply, gas, and electricity, New York City, remaining in this position until 1915, when he was made illuminating engineer for the Benjamin Electric Manufacturing Company of New York City. After 2 years of service with this company, he was commercial and illuminating engineer for the Westinghouse Lamp Company, New York, for 4 years, and manager of the interior illumination department of the Westinghouse Electric and Manufacturing Company for one year. During the past 10 years he has been general lighting representative of the Public Service Electric and Gas Company. He has contributed many technical papers on illumination. Among the societies of which he is a member are: Illuminating Engineering Society, National Electric Light Association, National Safety Council, The American Society of Municipal Engineers, Newark Safety Council, and Essex Electrical League. Mr. Blackwell has served on the Institute's committee on the production and application of light since 1924, and since 1931 has been its chairman, thus automatically becoming a member of the Institute's technical program committee.

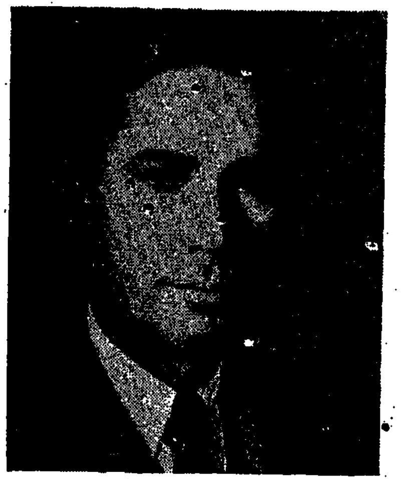
**W. R. Whitney** (A'01) organizer and for 32 years director of the research laboratory of the General Electric Company, Schenectady, N. Y., retired from that position owing to poor health on November 1, 1932. He was succeeded by Dr. **W. D. Coolidge** (A'10) formerly senior associate director of the laboratory. Doctor Whitney continues as vice-president in general charge of research. The research laboratory was established in 1900, and in that year Doctor Whitney came from Massachusetts Institute of Technology where he was an instructor, to be in charge of the research work. At that time the laboratory was in an old barn which was used by the late Dr. C. P. Steinmetz as a private laboratory. A few months later a small building at the General Electric works was secured. The expansion of the laboratory followed the development by Doctor Whitney of a new type of incandescent electric lamp, and since 1903 the laboratory has grown rapidly. By 1920 the laboratory's staff had grown to more than 300 persons, about half of whom were trained scientists; the value of this laboratory has long been recognized by the electrical industry. Among the many honors which Doctor Whitney has received was the Franklin Medal of the Franklin Institute on May 20, 1931. This award is made to "workers in physical science or technology without regard to country, whose efforts in the opinion of the administering committee on science and arts, have done most to advance a knowledge of physical science or its application." Doctor Whitney was assistant and later non-resident professor of theoretical chemistry at Massachusetts Institute of Technology, and is a member of the corporation of this institution.



W. R. WHITNEY

**A. LeRoy Taylor** (M'28), head of the department of electrical engineering, University of Utah, Salt Lake City, has been appointed chairman of the technical program committee for the 1933 Pacific Coast Convention of the Institute to be held in Salt Lake City during the summer of 1933. He was born at Logan, Utah, in 1887. He received the degree of B.S. in E.E. in 1907 from the University of Utah and the degree of master of science in engineering in 1918 from the University of Michigan, specializing in mechanical engineering. During 1910 and 1911 he was in the testing department and the standardizing laboratory of the General Electric Company at Schenectady, N. Y., thereafter being instructor in electrical engineering at the University of Utah for a one-year period. Following this he spent 2 years in business, returning to the University of Utah in 1914 and remaining there since that time. He has been assistant and later associate professor of mechanical engineering at this institution, and since 1928 has been head of the department of electrical engineering. Professor Taylor has served the Utah Section as a member of its executive committee 1930–31, secretary 1931–32, and chairman 1932–33. He has also been chairman of the Utah Section of The American Society of Mechanical Engineers and has been secretary of the Engineering Council of Utah.

**D. E. Renshaw** (M'29) in charge of the petroleum mining section of the general engineering department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., recently received reappointment as chairman of the Institute's technical committee on applications to mining work. Mr. Renshaw was born in Hennessey, Okla., in 1891. After completing his local high school course, he attended the University of Oklahoma, at Norman, from which he was graduated in 1914 with the degree of B.S. in E.E. Between 1912 and 1914 he was electrician at this university. Upon graduation he was on the student course of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., for a year. From 1915 to 1917, he was in the railway engineering department of that company. He then left to join the United States Navy, which he served for 2 years. In 1920 he returned to Westinghouse and remained in the railway equipment engineering department until 1923, after which for 2 years he represented the Westinghouse company in France and Spain, supervising erection of the car and locomotive equipment on the Paris-Orleans Railway and the Spanish Northern Railway. In 1925 he returned to the railway equipment engineering department of the Westinghouse company. Since 1928 he has been section engineer in charge of the mining section, general engineering department and for the past year has had charge of the petroleum section, also. Mr. Renshaw has served the Institute's committee on applications to mining work for the past 3 years and since 1931 has been its chairman. His other A.I.E.E. committee work has included membership on the technical program and standards committees since 1931.


D. E. RENSHAW

**W. D. Coolidge** (A'10) formerly senior associate director of the research laboratory of the General Electric Company, Schenectady, N. Y., was appointed on November 1, 1932, as director of this laboratory to succeed Dr. W. R. **Whitney** (A'01) who retired on that date. Doctor Coolidge is a native of Hudson, Mass. He studied at the Massachusetts Institute of Technology and the University of Leipzig. Since 1905 he has been active in the research work of the General Electric Company, becoming assistant director of the laboratory in 1908 and associate director in 1928. A personal item mentioning some of the achievements of Doctor Coolidge was given in Electrical Engineering for March 1932, p. 210–11, in connection with his winning the Washington award for 1932.

W. D. COOLIDGE

**J. H. Hamilton** (A'28), associate professor of electrical engineering at the University of Utah, Salt Lake City, has been appointed chairman of the student activities committee for the 1933 Pacific Coast Convention to be held in Salt Lake City. He was born at Los Angeles, Calif., in 1904 and graduated from the California Institute of Technology at Pasadena. After engaging as technical assistant on lightning research for the Union Oil Company of California and the General Petroleum Corporation, during 1926 and 1927, he became technical assistant for Kobe, Inc., Los Angeles, Calif., being engaged in the design of a magnetically controlled heat treating furnace. He was then for a while teaching fellow at the California Institute of Technology, and secured his doctor's degree from this institution in 1928. He is now Student Branch counselor at the University of Utah and an ex-officio member of the Institute's committee on student branches. For the year 1931–32 he was chairman of the North West districts committee on Student activities and a member of the excutive committee for this district. He is now a member of the executive committee of the Utah Section.

**Eugene Caldwell** (A'26), formerly chief mechanical engineer for the Central Public Service Corporation, Chicago, Ill., now is general manager of the Wrought Washer Manufacturing Company. Mr. Caldwell was editor-in-chief of *Industrial Power* for several years. He graduated from Ohio State University, Columbus, in 1922, and later took a special course at Massachusetts Institute of Technology, Cambridge, Mass. He is a member of the executive committee of the Institute's Chicago Section and chairman of the publicity committee of this Section. He is a member of The American Society of Mechanical Engineers, the publication committee of the Society of Industrial Engineers, and various committees of the National Electric Light Association. He is coauthor of a new textbook "American Industries," being used by New York University, and has contributed many articles to the technical press.

**C. E. Stephens** (M'22) formerly commercial vice-president and northeastern district manager of the Westinghouse Electric & Manufacturing Company, at New York, N. Y., was named vice-president. Mr. Stephens has been connected with the Westinghouse company since 1900, and with the New York office since 1917, having been appointed manager of the supply department in that year and later being made manager of the central station division, and in 1925 manager of the company's New York office. In 1930 he was elected commercial vice-president. He was at one time vice-president of the Illuminating Engineering Society. He has been active for many years in the A.I.E.E. and at present is a director of the Institute, chairman of the finance committee, and a member of several other of the Institute's committees.

**C. H. Douglas** (M'18) for some 12 years a St. Louis engineering-sales representative of various electrical manufacturing concerns now has become sales manager of the Industrial Products Sales Corporation, St. Louis. Mr. Douglas is a native of Walnut Ridge, Ark. (Feb. 5, 1886) graduated from the University of Arkansas in 1911 with degree of Bachelor of Science in electrical engineering, immediately after which he became associated with the Union Electric Light & Power Company of St. Louis; he became distribution engineer of that company in 1916. In June 1915 the University of Arkansas awarded him the degree of Electrical Engineer in recognition of advanced work completed.

**H. H. Barnes, Jr.** (A'00, M'04, F'13), vice-president of the General Electric Company, New York, N. Y., has been appointed chairman of the electrical industries and general machinery group of the Emergency Unemployment Relief Committee of

New York City, engaged in raising funds for unemployment relief during the winter 1932–3. This division, which is organizing 100 major trade groups through which funds will be solicited from employers, employees and employees' associations, last year raised more than $10,000,000 to finance "made" work and direct relief for the jobless. Last year Mr. Barnes headed the activities of the electrical industries for this committee.

**C. M. Lear** (M'31) has been appointed to serve as an instructor in the physics department of the University of Florida, Gainesville. Mr. Lear is a native of Charlottesville, Va. (Nov. 21, 1907); in 1930 he graduated from the University of North Carolina with the degree of Bachelor of Science in electrical engineering. For advance work he expects to receive in June 1933 from this same university his Master's degree in physics. He spent 2 years as a student engineer in the General Electric test department, Schenectady, N. Y. (1928–9 and 1930–1).

**F. H. Knapp** (A'28), who was assistant field engineer, area of the New York Telephone Company, for the Bell Telephone Laboratories, Inc., New York, N. Y., and later was located at St. Louis, Mo., engaged on work for the Southwestern Bell Telephone Company, now has returned to the Bell Telephone Laboratories, Inc., at New York, as field engineer, area of the Southwestern Bell Telephone Company. Mr. Knapp secured his E.E. degree from Rensselaer Polytechnic Institute in 1926.

**F. W. Smith** (A'05, M'12), who early this year became president of the New York Edison Company and the United Electric Light and Power Company, has been elected a member of the board of trustees of the Consolidated Gas Company, New York, N. Y. A personal item, outlining Mr. Smith's career, was given in ELECTRICAL ENGINEERING for March 1932, p. 210.

**E. W. Feller** (A'27) was recently transferred from the operating department of the Pennsylvania Water and Power Company at Holtwood, Pa., to the operating department of the Safe Harbor Water Power Corporation, Safe Harbor, Pa. Mr. Feller had been with the Pennsylvania Water and Power Company since 1924.

**G. R. Anderson** (A'22, M'29) in charge of the induction motor section of Fairbanks Morse & Company, Beloit, Wis., during the past year, recently was appointed chief engineer of the electrical division of the company.

**C. J. Huber** (A'13) formerly manager of the product engineering division of Cheny Brothers, South Manchester, Conn., is now engaged on special work with the U.S. Testing Company, Hoboken, N. J.

**H. R. Kelly** (A'28), formerly statistician in the quality department of RCA-Victor, Inc., Camden, N. J., is now administration head of the engineering department of this company.

**W. H. Pollard** (A'24) formerly an electrical engineer at the Indianapolis, Ind., works of Fairbanks Morse & Company, now is located in the Beloit, Wis., works of this company in the capacity of designing engineer.

## Obituary

**R. F. Schuchardt** (A'03, M'09, F'12, and past-president) chief electrical engineer of the Commonwealth Edison Company, Chicago, Ill., died in Boston, Mass., on October 25, 1932. Mr. Schuchardt had long been considered one of the foremost engineers of the United States. He was born in Milwaukee, Wis., in 1875, and in 1897 graduated from the electrical engineering course of the University of Wisconsin. Following graduation he spent a short period with the Janesville (Wis.) Electric Light and Power Company, later in that year he joined the staff of Meysenburg and Badt, Chicago, Ill., as engineering salesman. In July 1898, he entered the employ of the Chicago Edison Company (later the Commonwealth Electric Company and Commonwealth Edison Company) remaining with this organization until the time of his death. After a few weeks, first as substation operator and then in charge of the company's exhibit at the Trans-Mississippi Exposition, Omaha, Neb., he spent one year in the statistical department of the company. Between 1899 and 1906 he was in the testing department, through all stages from assistant to acting head. In 1906 he became engineer of electrical construction, having charge of this work for all stations and substations. In 1909 he was appointed electrical engineer of the company, and from that date to 1932 he has been intimately connected with the development of the company. He has made many contributions to technical literature since the presentation in 1897 of his first paper "Electricity Meters of Today" which attracted considerable attention. Mr. Schuchardt has long been active in the A.I.E.E., having served on many committees including the educational, power generation, power transmission and distribution, protective devices, standards, meetings and papers, executive, electrical machinery, law, Edison Medal, and public policy committees, as well as on the committee on code of principles of professional conduct. He has served as the Institute's representative on the U.S. national committee of the International Electrotechnical Commission, the administrative board of the American Engineering Council, the board of award of the John Fritz Medal, the Coffin fellowship and research fund committee, and on the joint committee of the engineering societies on participation of the engineering profession in the Century of Progress Exposition to be held in Chicago in 1933. From 1928 to 1929, Mr. Schuchardt was president of the Institute. He also was chairman of the Chicago Section of the Illuminating Engineering Society, chairman of the technical national section of the National Electric Light Association, member of the Western Society of Engineers, the Society for the Promotion of Engineering Education, and the Institution of Electrical Engineers of Great Britain. He has been chairman of the public affairs committee of the American Engineering Council, and in 1929 was a delegate to the World Engineering Congress in Japan.

**Edwin Nash Sanderson** (A'94, M'13, and Life Member) member of the firm of Sanderson and Porter, and president of the Federal Light and Traction Company, New York, N. Y., and of its 30 subsidiaries throughout the country, died November 9, 1932. He was born in Brooklyn, N. Y., in 1862. He attended Brooklyn Polytechnic Institute for 4 years and then attended Rensselaer Polytechnic Institute an additional 4 years, graduating with the degree of civil engineer in 1886. In 1887 he received the degree of M.E. from Cornell University. Between 1887 and 1896 he was with the Westinghouse Electric and Manufacturing Company, being an engineer at East Pittsburgh for one year, then engineer and salesman in New York for 5 years, manager of the New England district at Boston, Mass., for one year, and assistant to the general manager at East Pittsburgh for 2 years. In 1896 he resigned from the Westinghouse company; in this year the firm of Sanderson and Porter was formed and has since then remained active in the construction, management, and operation of electric railway, light and power properties. In 1910 his public utility holdings were incorporated into the Federal Light and Traction Company. Most of the major construction work of this company was performed by the firm of Sanderson and Porter, of which H. Hobart Porter (A'96, M'12, and Life Member), president of the American Water Works and Electric Company, Inc., New York, is the other senior member. One of Mr. Sanderson's major accomplishments was the construction in 1907 of one of the first hydroelectric projects in the Sierras, for the operation of the street railways of San Francisco, Calif. He was a member of The American Society of Mechanical Engineers, the Rensselaer Society of Engineers, the Cornell Society of Engineers, and Sigma Xi and Zeta Psi fraternities. He was a life member of the Board of Trustees of Cornell University. In 1925 Colgate University conferred upon him the honorary degree of Doctor of Law. Among his clubs were the University, City Midday, St. Bernard Fish and Game, Columbia Yacht, Town and Gown, and Cornell clubs, all of New York, the Union Club of St. John, N. B., and the Orchard Lake, Adirondack Mountain, and Westchester Country Clubs.

**D. H. Braymer** (M'15) head of the D. H. Braymer Equipment Company, Omaha, Neb., died October 29, 1932. He was born in 1883 at Hebron, N. Y. He secured his A.B. degree in 1906 from Cornell University, and his M.E. in E.E.

degree in 1908 from the same institution, having completed both mechanical and electrical engineering courses. During the summer of 1906 he was draftsman for the Morse Chain Company, Ithaca, N. Y., and during the summer of 1907 was electrical tester for the Electrical Testing Laboratories, New York, N. Y. He also held this latter position for a short time in 1908, becoming an engineer in the service and maintenance department of the New York plant of the Western Electric Company in that year. From 1909 to 1910 he was electrical engineer visiting and reporting on the Western Electric Company's power plant and telephone equipment in the capacity of publicity engineer. From 1910 to 1915 he was at Atlanta, Ga., on the staff of the *Southern Electrician* and succeeding magazines, being editor the latter part of this period. In 1915 he joined the McGraw-Hill Publishing Company as associate editor of the *Electrical World*, later becoming engineering editor, and then managing editor and coeditor. When the *Electrical Review* was purchased by the McGraw-Hill Company, Mr. Braymer was placed in charge of both the publishing and editorial policies of this magazine, which started under the name of the *Industrial Engineer*. In 1925, Mr. Braymer relinquished his editorial duties to organize the company which bears his name, specializing in consulting and sales work associated with power applications in industrial plants, large buildings, and power plants. He was at one time chairman of the Nebraska Section.

JOHN L. SWITZER (Enrolled Student) who recently received the Kruesi Improvement Prize awarded to senior students at the University of Tennessee, Knoxville, died October 1932. Mr. Switzer had been a student at the University of Tennessee, graduating from the electrical engineering course in June 1932 and had enrolled as a full-time graduate student for the coming year. The Kruesi prize, which he had just received, was established by Paul J. Kruesi of Chattanooga, for the benefit of engineering students at the University of Tennessee and is awarded each year to students of the graduating class who have been 3 years in attendance at the University of Tennessee. The award is made to that student of the senior class who by vote of the faculty of the college of engineering has made the most progress while a student, taking into consideration his preparedness, early opportunities, effort expended as a student, financial difficulties, ability, and activities outside of the curriculum. One prize is given in each of 4 engineering courses and covers the initiation fee and first year's dues in one of the following 4 engineering societies: American Chemical Society, The American Society of Mechanical Engineers, American Institute of Electrical Engineers and American Society of Civil Engineers. Mr. Switzer had been awarded membership in the Institute.

FRANK T. MORRISSEY (A'16) who for the past few years has been president of F. T. Morrissey & Company, Inc., Dallas, Texas, died September 10, 1932. Mr. Morrissey was born at Waltham, Mass., in 1885, and in 1900 was apprentice to I. A. Nourse, electrical engineer, Westboro, Mass., receiving special instruction in power plant design and maintenance. After serving between 1903 and 1906 in the U.S. Army, he was assistant to the chief engineer of the Saxony Worsted Mills, Newton, Mass., for 2 years. Between 1908 and 1910 he was district superintendent of the Eastern Michigan Edison Company at Wayne, Mich., and at Ann Arbor, Mich., thereafter being in the engineering department of the Kansas City Electric Light Company, Kansas City, Mo., for one year. He was at one time president and general manager of the Warren Light and Power Company, Inc., and later general superintendent of the Plymouth Electric Light and Power Company, Plymouth, Ind. This was followed by other similar engagements. His own company, which he organized a few years ago, was engaged as selling representatives and engineers for manufacturers' equipment.

IRA BURNARD MATTHEWS (A'17) superintendent of the transformer department of the Toledo Edison Company, Toledo, Ohio, died suddenly at his work October 25, 1932. Mr. Matthews was born in Defiance, Ohio, in 1877. In his youth he came to Toledo where he obtained his early education, later attending Toledo University. He remained in this city the rest of his life, being employed in 1894 by the Western Union Telegraph Company, in 1896 by the Harrison Telephone Company, in 1897 by the Buckeye Pipe Line Company, in 1901 by the Toledo Western Electric Railway, in 1903 by the Pennsylvania Railroad Company, and since 1905 by the Toledo Railways and Light Company, now the Toledo Edison Company. Mr. Matthews served as foreman in the line department of this company until the organization of the transformer department, when he was made superintendent of this department. He had a wide experience in the general construction of telephone, telegraph, and low and high voltage electrical equipment.

LEONARD G. VAN NESS (A'04), consulting engineer of Memphis, Tenn., and Lodi, Wis., died on September 24, 1932. He was born at Lodi in 1869 and graduated from the University of Wisconsin with the degree of B.S. in E.E. in 1896. He was then employed in the machine shop of the Elgin National Watch Factory at Elgin, Ill., for one year and was then engaged in power line construction for a year. Between 1898 and 1902 he was electrical engineer with Emerson-McMillan Company engaged in central station work for companies in a number of different cities. In 1902 he became general manager of the Lincoln Gas and Electric Light Company at Lincoln, Nebraska. Later he was an official of the Memphis (Tenn.) Gas and Electric Company and remained active in public utility construction during his career. He had a wide experience in construction and rehabilitation of gas and electric properties and was considered an expert in analyzing the costs of operation and in conducting rate investigations.

WALTER L. WOODMANSEE (A'23) chief electrician of the American Steel and Wire Company, South Works, Worcester, Mass., died recently as a result of severe burns received while making some electrical connections at the plant. Mr. Woodmansee was born in 1875 in Noank, Conn. Between 1896 and 1898, he was engaged in the construction and testing of electrical motors and generators at the Eddy Electrical Company, Windsor, Conn., and between 1898 and 1902 was installing and repairing motors and generators for the W. C. McIntire Company, Philadelphia, Pa. For 2 years following 1902, he undertook electrochemical experimental work for Rogers and Hite, Conshohocken, Pa., after which he spent 2 years rebuilding electrical machinery for Yearsley and Levene, Philadelphia, Pa. From 1906 until the time of his death, he held the position of chief electrician at the plant of the American Steel and Wire Company.

WILLIAM ALEXANDER BARRETT (A'07) died on May [illegible], 1932, according to word recently received at the Institute headquarters. He was born at Wadesboro, N. C., in 1881, and was a graduate of the North Carolina Agricultural and Mechanical College in the electrical engineering course. Following graduation he was employed by the Union Electric Company of St. Louis, Mo., as meter inspector for one year, and later held a similar position with the Missoula Light and Water Company at Missoula, Mont. More recently, Mr. Barrett was electrician at the Puget Sound Navy Yard, Bremerton, Wash.

# Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Anderson, F. C., 741 Oak Ave., Westfield, N. J.
Bohner, C. W., 620—22nd Terrace, Miami, Fla.
Brock, Geo., 1117 N. 15th St., Milwaukee, Wis.
Florez-Estrada, Jose, Avenida De La Paz 60, Reparto Alture-Rio Almendares, Marianao, Havana, Cuba.
Heiser, Edwin S., 413 Federal Bldg., St. Paul, Minn.
Jefferson, H. F., 633 Portola Ave., Glendale, Calif.
Katz, Henry, 2714 Wallace Ave., New York, N. Y.
Keller, Dr. Max Leo, Kornweg 8, Aarau, Switzerland.
Kirby, F. M., 25 E. 40th St., New York, N. Y.
McShane, Joe B., 810 Western Natl. Bldg., San Antonio, Texas.
Newman, Rexford C., 100 High St., St. Clairsville, Ohio.
Nimetz, John B., 3442 Sacramento St., San Francisco, Calif.
Olsen, V., P. O. Box 404, Shanghai, China.
Peterson, Alex., Central West Pub. Serv. Co., Omaha, Nebr.
Schatz, Nathan, 1845—52nd St., Brooklyn, N. Y.
Shen, C. Mayo, 18 an Check L8, Scott Rd., Shanghai, China.
Uline, Wm. A. Northern Elec. Co., Guy & Notre Dame Sts., Montreal, Que., Can.

# Local Meetings

## Past Section Meetings

**Akron**

Electrical Installations of Guggenheim Institute, by Prof. J. T. Walther, Akron Univ. Demonstration in airport lighting upon the arrival and departure of a tri-motor plane from Pittsburgh. Different Types of Wind Tunnels, by Dr. Theodore Troller, resident director of Guggenheim Institute. Demonstrations. Oct. 11. Att. 73.

**Atlanta**

The Engineer's Place in the Sun, by Prof. W. E. Freeman, Univ. of Kentucky, vice-pres., A.I.E.E. Oct. 7. Att. 45.

**Boston**

Inspection trip through the new laboratories at Mass. Inst. of Tech. Oct. 19. Att. 90.

**Cincinnati**

Symmetrical Components, by A. W. Lewis, Westinghouse Elec. & Mfg. Co. Illustrations. Oct. 13. Att. 65.

**Cleveland**

Electric Shock, by Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres., A.I.E.E. Oct. 20. Att. 102.

**Columbus**

Air Conditioning Development, by R. E. Robillard, Frigidaire Corp. Oct. 28. Att. 36.

**Connecticut**

Seeing, by Dr. Matthew Luckiesh, Gen. Elec. Co. Joint meeting with Engrs. Club of Hartford. Sept. 29. Att. 200.

Design and Manufacture of Small Motors and Generators, by D. G. Shepherd, E. W. Borggrafe, and W. H. Haines, all of the Electric Specialty Co. Oct. 26. Att. 59.

**Dallas**

Overhead Conductor Vibration, by R. A. Monroe, Aluminum Co. of America. Illustrated. Oct. 17. Att. 61.

**Denver**

The Human Side of Constructing Engineers, by Prof. F. V. Bliss. Dinner. Oct. 21. Att. 24.

**Detroit-Ann Arbor**

The Public Utility Dollar—Where It Comes From and Where It Goes, by A. C. Marshall, Detroit Edison Co. Dinner. Oct. 18. Att. 160.

**Fort Wayne**

The Dependence of Air Transportation on the Electrical Engineer, by C. F. Green, Gen. Elec. Co. Illustrated. Oct. 11. Att. 115.

**Houston**

Industrial Engineering and the Electric Utilities, by L. K. Del'Homme, Houston Lighting & Power Co. Dinner. Oct. 26. Att. 13.

**Indianapolis-Lafayette**

Low Voltage Circuit Protection Without the Use of Fuses in Combination With the Deion Principle of Arc Extinction, by H. G. Nichols, Westinghouse Elec. & Mfg. Co. Illustrated. Oct. 18. Att. 72.

**Kansas City**

The Design and Purpose of Electric Dispatching Boards, by T. V. White, Amer. Automatic Elec. Sales Co.; Television, by G. L. Taylor, First National Television Co. Demonstrations. Oct. 25. Att. 65.

**Lehigh Valley**

Electrons at Work and at Play, by Phillips Thomas, Westinghouse Elec. & Mfg. Co. Demonstrations. Prize of $25 awarded to W. H. Lesser for the best local technical paper. Joint meeting with Engrs. Club, held at Hotel Traylor, Allentown. Oct. 14. Att. 650.

**Los Angeles**

The Industrial Aspect, by W. L. Moreland. Moreland Motor Truck Co.; The Transportation Aspect, by Frank Carr, Pacific Elec. Co.; The Financial Aspect, by O. E. Monnette. Bank of America. Joint meeting with A.S.C.E., A.S.M.E., and A.I.M.E. Oct. 12. Att. 600.

**Louisville**

Inspection trip to Dix River Dam. Oct. 29. Att. 35.

**Lynn**

Chasing News With a Camera, by A. H. Blackington. Illustrated. Oct. 19. Att. 475.

Professor Nichols, of Tufts College, conducted an inspection trip to Nahant, Beach Bluff, and Salem to show local geological formations of particular interest. Oct. 29. Att. 35.

The Solar Eclipse, by Dr. D. H. Menzel, Harvard Observatory Staff. Nov. 2. Att. 800.

**Madison**

The Edgewater Plant, by W. S. Campbell, Wisconsin Pwr. & Lt. Co. Dinner. Nov. 2. Att. 42.

**Memphis**

Activities of the War Industrial Board, by Major E. C. Kelton, U.S. Engineers' Corps. Oct. 24. Att. 33.

**Mexico**

Annual banquet. Oct. 29. Att. 40.

**Minnesota**

Economics in Relation to Public Utilities, by Prof. J. M. Bryant, Univ. of Minnesota. Oct. 27. Att. 20.

**New York**

The Utility's Problem, by H. R. Searing, N. Y. Edison and United Elec. Lt. & Pwr. Co.; The Contractor's Problem, by Allen Coggeshall, Hatzell & Buehler, Inc. Power group meeting. Oct. 14. Att. 400.

Air Conditioning as a Potential Factor in National and World Economics, by W. H. Carrier, Carrier Engg. Co. Oct. 26. Att. 450.

World-Wide Telephony, by Bancroft Gherardi, Amer. Tel. & Tel. Co. Communication group meeting. Nov. 1. Att. 525.

**Niagara Frontier**

Rational Control of Motor Starting Currents, by R. T. Henry, Buffalo, Niagara & Eastern Pwr. Co. Oct. 21. Att. 65.

**Oklahoma City**

Vibration of Overhead Conductors, by R. A. Monroe, Aluminum Co. of Amer. Oct. 20. Att. 54.

**Philadelphia**

Adventures in Science, by E. L. Manning, Gen. Elec. Co. Oct. 10. Att. 125.

**Pittsburgh**

Electric Shock, by Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres., A.I.E.E. Oct. 19. Att. 114.

**Pittsfield**

Japan, China, and the White Man, by Upton Close. Nov. 1. Att. 1100.

**Portland**

Annual dinner with six speakers. Joint meeting with N.E.L.A. Oct. 18. Att. 57.

**Providence**

General Electric Oil Furnace, by F. A. Durkin, Gen. Elec. Co. Oct. 11. Att. 60.

The Narragansett Electric Distribution System, by Orie Van Rye, New England Pwr. Engg. and Serv. Corp. Nov. 9. Att. 60.

**St. Louis**

Oil-Filled, Self-Cooled Transformers by Temperature, by H. B. Keath, Wagner Elec. Corp. Oct. 19. Att. 69.

**San Antonio**

San Antonio's New Automatic Telephone System, by B. D. Hull, Southwestern Bell Tel. Co. Inspection trip through the plant. Sept. 26. Att. 142.

Vibrations in Overhead Conductors, by R. A. Monroe, Aluminum Co. of Amer. Demonstrations. Oct. 18. Att. 42.

**San Francisco**

The European Viewpoint, by Frank Copley; Proposed Boulder Dam Transmission Line, by Bradley Cozzens, Bureau of Pwr. & Lt. of the City of Los Angeles. Dr. J. F. Carroll explained the laboratory equipment and tests to be witnessed. Oct. 19. Att. 250.

**Saskatchewan**

Banquet. Joint meeting with E.I.C. Oct. 21. Att. 22.

**Schenectady**

Methods of Obtaining Colored Motion Picture Films, by J. G. T. Gilmour, Gen. Elec. Co. Oct. 6. Att. 125.

**Sharon**

Electrons at Work and at Play, by Dr. Phillips Thomas, Westinghouse Elec. & Mfg. Co. Film—"Dynamite." Oct. 21. Att. 230.

**Springfield**

Total Eclipses of the Sun, by B. V. K. French, Amer. Bosch Magneto Corp. Illustrated. Oct. 10. Att. 71.

**Toledo**

Executive committee meeting. Oct. 6. Att. 8.

Soviet Russia, by Mr. Buchenburg, Electrical Autolite Co. Oct. 12. Att. 18.

Fundamentals of Magnetism, by W. W. Cummins, Toledo Edison Co.; Effects of Electric Shock, by Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres., A.I.E.E. Oct. 21. Att. 160.

**Toronto**

Recent Developments in Air Breaker Switching, by W. Gilson, Eastern Pwr. Devices. Oct. 14. Att. 90.

The Foundations of Science, by W. F. Sutherland, Toronto Hydroelectric System. Oct. 28. Att. 50.

**Washington**

Light, by Prof. L. D. Bliss, Bliss Electrical School. Oct. 11. Att. 90.

**Worcester**

Illumination, by W. E. Haycock, Gen. Elec. Co.; Radio, by Prof. H. H. Newell, Worcester Poly. Inst.; Air Conditioning, by E. D. Learned, Worcester Elec. Lt. Co.; Electric Heating of Buildings, by W. A. Sutphen, New England Pwr. Engg. & Serv. Corp.; Telephone, by J. W. Kidder, New England Tel. & Tel. Co. Dinner meeting. Oct. 18. Att. 43.

## Future Section Meetings

**Boston**

December 13—Lightning Arrestors, by Messrs. Corney and Haynes.

January 10, 1933.—International Communication.

**Cleveland**

December 15—Submarine Treasure Hunting With Underwater Lamps, by E. W. Beggs, Westinghouse Lamp Co. Joint meeting with Ill. Engg. Soc., at Westinghouse Lighting Studios. Edgewater Park.

January 19, 1933—Social meeting.

**Detroit-Ann Arbor**

December 13, at Detroit, Mich.—Electric Motors and Their Applications, by A. M. Dudley, Westinghouse Elec. & Mfg. Co.

January 17, 1933, at Detroit, Mich.—Extending Our Frontiers Through Research and Engineering, by H. P. Charlesworth, pres., A.I.E.E., vice-pres., Bell Tel. Labs., Inc.

**Fort Wayne**

December 7, at Chamber of Commerce.—Design and Application of Demand Meters, by H. M. Witherow, Gen. Elec. Co.; Performance Calculations for Special Stationary Apparatus, by M. L. Schmidt, Gen. Elec. Co.

January 17, 1933, at Home Tel. & Tel. Auditorium.—Dial Controlled Robots, by H. M. Bruckart, Home Tel. & Tel. Co.; A New Development in Oven Control, by R. M. Hartigan, Gen. Elec. Co. Inspection of the Fort Wayne Telephone Exchange.

**Lehigh Valley**

December 9, at Berkshire Hotel, Reading, Pa.—Three Years Progress in Field Investigation With Artificial Lightning, by K. B. McEachron, Gen. Elec. Co.; Reversed Refrigeration for House and Water Heating, by G. Wilkes, W. F. Barstow Co.

**Pittsfield**

December 6—Rovings of a German Sea Raider, by Captain Julius Lauterbach.

December 20—Theory of the Expanding Universe, by Dr. Harlow Shapley.

January 3, 1933—By Air to Inca Land, by Robert Shippee.

January 17, 1933—Modern Railway Electrification—With Special Reference to Pennsylvania System, by J. V. B. Duer, Pennsylvania RR. Co.

**Toledo**

December 16—Lighting the Modern City, by L. A. S. Wood, Westinghouse Elec. & Mfg. Co.

January 13, 1933—Air Conditioning, by H. B. Matzen, Carrier Corp.

**Toronto**

December 16—Applications of Synchronous Motors, by Leech-Porter.

January 19, 1933—Coordination of Insulation, by W. W. Lewis.

January 27, 1933—Astronomy and the Dunlap Observatory, by Prof. Chant, Univ. of Toronto.

## Past Branch Meetings

**University of Alabama**

The Commercialization of the X-Rays, by W. K. Price, student. Oct. 16. Att. 29.

The Power Distribution of Transit Lines, by F. B. Gaines, student. Oct. 24. Att. 24.

**University of Arkansas**

Benefits of Membership in the A.I.E.E., by Dean W. N. Gladson. Oct. 6. Att. 37.

A review of the papers and events at the Conference on Student Activities, held at the University of Oklahoma, was given by several students. Oct. 27. Att. 32.

The American Engineer in Russia, by G. Smith, student; Investigation of Single Energy Transients, by W. D. Thornberry, student; Engineering From the Sales Viewpoint, by C. E. Bradley, Gen. Elec. Co. Nov. 3. Att. 34.

**Armour Institute of Technology**

Discussion of Branch activities. Oct. 7. Att. 31.

Air Conditioning, by M. J. Maiers, Central Station Institute. Illustrated. Oct. 21. Att. 35.

Motion pictures. Nov. 4. Att. 30.

**University of British Columbia**

Western Electric Speech Input Equipment, by W. Smith, student; Photo-Telegraphy, by L. Rader, student. Oct. 13. Att. 13.

**Polytechnic Institute of Brooklyn**

The Applications of the Photoelectric Cell in the Holland Tunnel, by Prof. Robin Beach. Refreshments. Nov. 2. Att. 65.

**California Institute of Technology**

M. S. Hodge, chmn., gave a report of the Pacific Coast Convention held in Vancouver. Prof. R. W. Sorensen, counselor, gave a summary of the work carried on by the A.I.E.E. Oct. 14. Att. 26.

H. C. Fracker, Bell Tel. Labs., Inc., gave a demonstration and lecture of the newly developed vertical cut phonograph records, recording, and amplification system. Oct. 20. Att. 300.

**University of California**

The Application and Operation of the Teletypewriter, by R. Tibbetts and V. Tonjes, students. Motion pictures. Sept. 21. Att. 51.

Initiation banquet. Problems Found in the Engineering, Social, and Economic Fields, by Dr. Ira B. Cross. Sept. 23. Att. 57.

**Carnegie Institute of Technology**

The Development of the Carnegie Tech. Branch of the A.I.E.E., by Prof. G. Porter, counselor; Place of an Engineer in Engineering Society, by Dr. W. R. Work; Benefits I Have Derived From Membership in the A.I.E.E., by Dr. C. E. Skinner, Westinghouse Elec. & Mfg. Co. Oct. 17. Att. 27.

Testing Railroad Tracks by Means of the Sperry Railroad Car, by Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres., A.I.E.E. Oct. 19. Att. 90.

**Case School of Applied Science**

Prof. J. R. Martin described his work in connection with the eclipse. Oct. 21. Att. 31.

**Catholic University of America**

Election of officers: J. Springman, pres.; R. Bourne, vice-pres.; T. J. Nally, secy.; F. Hurson, treas. Oct. 4. Att. 20.

**Clemson Agricultural College**

Executive meeting. Oct. 4. Att. 51.

A Modern European Power Plant, by M. G. Miller, student; The Development of Electrical Machinery in the U.S., by H. A. Clayton, student; current events, by E. B. Shaw, student. Oct. 25. Att. 34.

**Colorado Agricultural College**

Prof. G. Z. Dimitroff outlined his trip to New England to photograph the total eclipse of the sun. Joint meeting with A.S.M.E. branch. Oct. 24. Att. 26.

**University of Colorado**

The Construction, Management, and Functions of the A.I.E.E., by Prof. W. C. DuVall, counselor, and Prof. M. S. Coover, District secy. A.I.E.E. Oct. 5. Att. 53.

My Vacation Tour of France, Switzerland, Germany, and England on a Bicycle, by J. M. Evans, student. Illustrated. Joint meeting with A.S.M.E. Branch. Oct. 19. Att. 52.

**Cornell University**

Political Issues and the Stock Market, by J. W. McWilliams, student; The Making of Lateral Cut Records on Aluminum Disks, by J. W. Conn, student. Oct. 28. Att. 25.

**University of Denver**

Electrical Engineering and Senior Branch of A.I.E.E., by Prof. R. E. Nyswander, counselor. Oct. 11. Att. 20.

Inspection trip through the terminal station and two substations of the Public Service Co. of Colo. Att. 12.

**University of Detroit**

Lighting of the Campus and Power Factor Correction, by Prof. H. O. Warner, counselor. Films—"Vacuum Tube Synchronization," "Synchronizing Machine Construction." Oct. 27. Att. 42.

**Duke University**

The Advantages and Disadvantages of Double Conductor Transmission Lines, by D. E. Cook, student; The Expansion of Electrical Engineering Fields, by W. J. C. Brown, student. Oct. 18. Att. 27.

Fallacies of Mathematics, by Wm. Karpinsky, student; The Engineer's Place in the Sun, by Prof. W. E. Freeman, Univ. of Kentucky, vice-pres., A.I.E.E. Nov. 3. Att. 33.

**University of Florida**

The Florida Portland Cement Plant at Tampa, Fla., by J. B. Smith, student; Things of Interest in the Bell Telephone Laboratories, by E. L. Stuhrman, student. Oct. 18. Att. 40.

**University of Idaho**

Films—"Manufacturing Mazda Lamps," and "Power Transformers." Dinner. Oct. 4. Att. 26.

**University of Illinois**

The Theory of Oscillatory Circuits, by Mr. Veach, student. Film—"The Electric Ship." Oct. 12. Att. 127.

**University of Iowa**

R.O.T.C. Summer Camp Life, by T. R. MacDougall, student. J. W. Blessing elected secy. Oct. 5. Att. 31.

General discussion and inspection of the new dial telephone exchange. Oct. 12. Att. 32.

Dial Telephone Systems, by H. Hammond, student; Elimination of Radio Interference, by A. Shradel, student. Oct. 26. Att. 38.

Flood Lighting, by C. Bartholow, student; Guiding Airplanes by Radio, by Wm. Benineosa student. Nov. 2. Att. 36.

**University of Kentucky**

Election of officers: R. H. Gray, pres.; E. W. Graham, secy.-treas. Sept. 21. Att. 48.

**Lehigh University**

Airport Lighting, by W. D. Hickman, student; My Experiences at Harvard and M.I.T., by Prof. J. L. Beaver. Committees appointed. Oct. 7. Att. 50.

The Cosmic Ray, by Dr. R. A. Millikan, Calif. Inst. of Tech. Oct. 26. Att. 780.

**Lewis Institute**

Prof. F. A. Rogers, counselor, outlined the privileges and advantages of student enrolment in the A.I.E.E. Oct. 18. Att. 120.

Election of officers: I. R. Ekstrom, pres.; Walter Bohne, secy.-treas. Nov. 3. Att. 86.

**Louisiana State University**

Discussion. Nov. 3. Att. 21.

**University of Louisville**

Dix River Dam Electric Power Project, by Mr. Jefferson, student. Film—"Pathways of Progress." Nov. 7. Att. 23.

**Michigan College of Mining and Technology**

Prof. G. W. Swenson, counselor, outlined the advantages of membership in the A.I.E.E. Oct. 13 Att. 42.

Distribution, by I. H. Gronseth, Board of Water & Elec. Lt. Comm. Oct. 19. Att. 46.

Inspection trip to the Howell Motors Co. Oct. 26. Att. 17.

Ultra short wave radio demonstration. Nov. 2. Att. 41.

**University of Michigan**

Election of officers: J. M. Lyon, chmn.; G. Leland, vice-chmn.; I. J. Sattinger, secy.; D. J. Carr, treas. Film—"Nature's Frozen Credits." Oct. 17. Att. 54.

**Milwaukee School of Engineering**

Electric Sectional Drive for Paper Making Machinery, by E. H. Laabs, Cutler-Hammer Mfg. Co. Oct. 12. Att. 76.

**University of Minnesota**

Experiences at Oxford, by Fred Hovde. Oct. 12. Att. 110.

**Mississippi State College**

Discussion. Oct. 12. Att. 30.

**University of Missouri**

Synchronous Motors, by C. Haines and F. Hubbell, students. A. Coffman, student, outlined the Conference on Student Activities, held at the Univ. of Okla. Nov. 2. Att. 27.

**Montana State College**

X-Ray and Cathode Ray Tubes in Biological Service, by L. Ambrose; The Engineer in a Changing Society, by R. V. Bauer; Underground Conduit Construction, by J. Cromer; A Noiseless and Flameless High-Voltage Fuse, by Loran Eisele; Erecting Poles With Conductors Attached, by C. L. Grebe, all students. Oct. 13. Att. 86.

Welding Steel Structures, by Rex Wyman; A 115,000 Kw. Turbo-Alternator, by E. Rothaus; Radio and Television, by T. Degenhart and J. Lightfoot, all students. Oct. 20. Att. 89.

The Characteristics of Some Miniature Lamps, by D. A. Nauck; Highway Lighting, by J. Antonich; Visiting Butte's Greatest Industry, by M. Axelson; Further Research in Injuries From Electric Shock, by C. Bergland, all students. Oct. 27. Att. 95.

**University of Nevada**

Discussion. Oct. 7. Att. 7.

**Newark College of Engineering**

Members attended the George Washington Bicentennial celebration, sponsored by the joint professional engineering societies of Essex County, at which Roy V. Wright, editor of *Railway Age*, spoke on George Washington, The Engineer. Oct. 19. Att. 25.

**University of New Hampshire**

Film—"Anthracite." Sept. 24. Att. 31.

Testing Paper for Electrical Insulation, by H. T. Dickson; Correcting Readings Taken on Small Power Motors, by A. E. Dogan; Eddy Currents, by H. W. Feindel; E. Horne covered the question box in Electric Journal, all students. Oct. 1. Att. 27.

Nothing More Modern, by H. W. Machon; An Ordeal by Water and Eddy Currents, by O. Abbiatti; Mechanical Vibration Research, by A. F. Allen; The Clock on the Mantel, by E. L. Huse, all students. Oct. 15. Att. 32.

Types of Supply for Three Wire Systems, by C. W. Quimby; Fusing the Neutral of a Three Wire System, by H. W. Hamm; The Homopolar or Unipolar Generator, by R. C. Loeschner; Gun Recoil Control, Metalized Wood, and Invisible Wire Hair, by M. H. Sargent, all students. Oct. 29. Att. 29.

**College of the City of New York**

Industrial Control Problems, by O. H. Diefendorfer, Gen. Elec. Co. Oct. 20. Att. 51.

Discussion. Oct. 27. Att. 29.

**New York University**

Prof. H. N. Walker, counselor, outlined future plans. Oct. 14. Att. 18.

The Photoelectric Cell, by Mr. Zdanowitz, student; Push-Pull Amplifiers, by Mr. Christie, student. Oct. 28. Att. 20.

**North Carolina State College**

The Electric Power Development in Syria, by J. R. Salem, student; Engineering Topics of the Day, by C. M. Smith, Jr., student. Oct. 18. Att. 42.

Counting Salmon in Alaska, by J. S. Culbertson, student; Engineering Topics of the Day, by C. M. Smith, Jr., student; Technocracy, by F. E. Brammer, student. Nov. 1. Att. 35.

**University of North Carolina**

The Aims, Functions, and Organization of the A.I.E.E., by Prof. J. F. Lear, counselor; The A.I.E.E. Convention at Cleveland, by Prof. E. W. Winkler. Oct. 13. Att. 50.

**University of North Dakota**

Caissons, by Boyd Begg, Raymond Concrete Pile Co. Oct. 5. Att. 21.

Talk by P. J. Montgomery, Northern States Pwr. Co. Oct. 19. Att. 21.

Film—"Electricity Goes to Sea." Nov. 3. Att. 17.

**University of Notre Dame**

Electrical Applications to Municipal Government, by E. A. Qualls, supt., City Electrical Dept. of South Bend. Oct. 19. Att. 70.

Making a Living With an Engineering Education, by J. P. Kennedy; Patents—How to Get One and the Cost, by Leo Hanlon, student; Electrification of the Great Northern Railway, by John Land, student; P. McCaffary, student, gave the bi-weekly review of current engineering news. Nov. 2. Att. 54.

**Ohio State University**

History and Founding of the A.I.E.E., by Prof. F. C. Caldwell, counselor; The Engineer in Industry, by Prof. Bibber. Oct. 13. Att. 40.

**Ohio University**

Prof. A. A. Atkinson, counselor, and J. Hoskinson, chmn., outlined the advantages of membership in the A.I.E.E. Oct. 10. Att. 23.

Remote Control of Ships From Land Stations, by W. Cooper and C. Eddy, students. Oct. 19. Att. 14.

How Electricity Received Its Start in Athens, by Prof. A. A. Atkinson, counselor. Nov. 2. Att. 15.

**University of Oklahoma**

Prof. F. G. Tappan, counselor, explained student enrolment in the A.I.E.E. Oct. 5. Att. 18.

**Oregon State College**

Acceptance Test of the Rock Island Hydraulic Unit, by J. F. Spease, Gen. Elec. Co. Oct. 20. Att. 39.

**Pennsylvania State College**

Smoker. Oct. 5. Att. 60.

**Rensselaer Polytechnic Institute**

Construction of the New Transmission Line Between Albany and Westchester Counties, by A. G. Stockrott, N. Y. Pwr. & Lt. Corp. Oct. 18. Att. 350.

**Rhode Island State College**

Film—"Nature's Frozen Credits." Oct. 13. Att. 25.

Michaelson's Experiments on the Velocity of Light, by Prof. Wm. Anderson, counselor. Oct. 20. Att. 16.

Industrial Applications of the Thyratron Tube, by E. A. Hancock and A. J. Moore, both of the General Elec. Co. Nov. 2. Att. 175.

**Rutgers University**

Discussion. Oct. 4. Att. 19.

Practical Testing of Telephone Cables, by L. M. Leeds, Amer. Tel. & Tel. Co. Oct. 18. Att. 19.

Film—"Conowingo." Nov. 1. Att. 41.

**University of Santa Clara**

Industrial Achievements in Other Countries, by Warren McBride. Joint meeting with A.S.M.E. Branch. Oct. 7. Att. 66.

**University of South Carolina**

Television, by G. W. Arrants; The Liner That Cannot Roll, by T. J. Bennett; Electric Aids to Medicine, by S. A. Black, all students. Oct. 10. Att. 33.

Night Lighting for Outdoor Sports, by D. W. Cardwell; Radio and Dynamite Find Earth's Secret Riches, by T. H. Coughman; Electric Ship California, by C. L. Bradley, all students. Oct. 17. Att. 34.

More Power to Canada, by R. F. Cuthbertson, student; Photoelectric Control of Paper Cutter Register, by N. J. Christensen, student. Oct. 24. Att. 35.

Radio Activity, by M. Garris; Welding, by L. Folson, Overseas Telephony, by A. G. Daniels, all students. Oct. 31. Att. 33.

**South Dakota State School of Mines**

Discussion. Oct. 12. Att. 25.

Albert Hall elected vice-chmn., and Charles Reed elected secy.-treas. Oct. 21. Att. 26.

**University of Southern California**

The Essentials of a Successful Engineer, by Mr. Rowley, Los Angeles Bureau of Water and Power. Sept. 21. Att. 26.

Engineer and His Social Aspects, by Dean Bacon. Sept. 28. Att. 20.

High Head, Remote Control, Pumping Station at Boulder Dam, by W. F. Grimes, Westinghouse Elec. & Mfg. Co. Oct. 5. Att. 29.

Banquet. Oct. 13. Att. 24.

**Southern Methodist University**

Recent Developments in the Metering of Electrical Energy, by M. P. Jones, student. Oct. 19. Att. 8.

**Stanford University**

Events at the Pacific Coast Convention, held in Vancouver, outlined by several students. Oct. 11. Att. 30.

**Stevens Institute of Technology**

Rolls Royce Type R Engine Used in the Schnieder Trophy Races, by Prof. E. Fezandie. Oct. 7. Att. 44.

**Syracuse University**

Crystal Control of the Vacuum Tube, by A. Adams, student; Radio Beacons, by C. P. Bower, student. Oct. 11. Att. 23.

Power Transmission, by J. S. Brzostek, student; X-Rays, by R. Bradshaw, student. Oct. 18. Att. 23.

Power Transmission and Distribution in Syracuse, by A. Carley, student; Static Elimination in Radio Sets, by C. M. Crysler, student. Oct. 25. Att. 20.

Inspection trip to hydroelectric power plants at Salmon River and Oswego. Nov. 1. Att. 21.

Harmonic Analysis, by Prof. C. W. Henderson, counselor; Electrical Home at Present, by L. E. Dawley, student; Electrical Home of the Future, by N. F. Emig, student. Nov. 8. Att. 21.

**University of Tennessee**

Discussion of future activities. Oct. 5. Att. 20.

Films—"Sugar Cane Industry in Cuba" and "Construction of the Panama Canal." Oct. 19. Att. 25.

Characteristics of a Mercury-Vapor Tube, by A. C. Seletzley and S. T. Shevki, presented by Wiley Patton, student. Review of current events given by Mr. Lerch, student. Nov. 2. Att. 14.

**Texas A. & M. College**

Election of officers: G. H. Samuels, chmn.; W. E. Steele, vice-chmn.; J. I. Walton, secy.-treas. Oct. 4. Att. 80.

Why Modern High Speed Railway Service Is Possible, by H. B. Yarbrough; Stray Losses of a D.C. Dynamo, by J. K. Jones; Permeability Tuning of Broadcast Receivers, by C. C. Johnston; An Ultra Short Wave Transmitter, by G. C. Hutcheson; Lightning Protection, by A. J. Ismeal, all students. Oct. 11. Att. 26.

Film—"Conowingo." Oct. 27. Att. 90.

**Texas Technological College**

The Aims and Purposes of the Student Branches, by J. Preston Conner, student. The Advantages of a Technical Education, by Dr. Bradford Knapp. Oct. 5. Att. 29.

**University of Texas**

W. B. Hurt elected corresponding secy. Oct. 5. Att. 28.

Some Fundamentals on Inductive Coordination, by David Sussin, student. Oct. 13. Att. 12.

**University of Utah**

Film—"A Trip Through the G. E. Plant." Oct. 26. Att. 36.

New Transmitter Equipment at Station KSL, by E. G. Pack, radio engr. at that station. Nov. 2. Att. 38.

**University of Virginia**

Discussion. Oct. 14. Att. 14.

The Engineer's Place in the Sun, by Dean W. E. Freeman, Univ. of Kentucky, vice-pres., A.I.E.E. Oct. 20. Att. 24.

**Virginia Military Institute**

Armature and Stator Windings, by N. W. Dingman; Elevator Service in Our Modern Skyscrapers, by J. T. Taylor; Improving the Prestige of the Engineering Profession, by G. S. Bernard; The Story of Frequency, by C. E. Schoonover, all students. Sept. 23. Att. 111.

Nothing More Modern, by R. S. Singleton; Electric Locomotives, by J. M. Troutt; Motor Car Design, by G. C. Wilson; Guiding Airplanes by Radio, by T. R. Wise, all students. Oct. 1. Att. 106.

**Virginia Polytechnic Institute**

Film—"Conowingo." Oct. 13. Att. 168.

The Engineer's Place in the Sun, by Prof. W. E. Freeman, Univ. of Kentucky, vice-pres., A.I.E.E. Oct. 21. Att. 66.

Highway and Street Lighting, by W. E. DeBrick; Reversed Refrigeration, by G. Giles, Jr.; Too Many Engineers, by E. H. Farley; Communication as an Aid to Transportation, by J. L. Brown; Philadelphia's New Electrical Structure, by R. P. Haskins, all students. Oct. 27. Att. 42.

**State College of Washington**

General discussion. Oct. 14. Att. 25.

**University of Washington**

Frequency Modulation of Radio Waves, by E. D. Scott, student. Oct. 13. Att. 25.

Business Conditions as They Affect the Student, by L. E. Karrer, Puget Sound Power & Light Co. Oct. 20. Att. 21.

Film—"Nature's Frozen Credits." Oct. 27. Att. 23.

**West Virginia University**

Taming a Tropic Torrent, by R. H. Colborn; Longest Telephone Cable in the World, by U. A. Chapman; Is Radio Making Us a Race of Morons? by J. G. Henderson; Type 57 Radio Tube, by N. I. Hall; Experience in Testing Porcelain, by J. E. Wallace; Thermostatic Control on Motor Circuits, by M. B. Tolley; Life of Benjamin Carver Lamme, by R. Marshall, all students. Oct. 10. Att. 22.

Synchronous Motor Effect in Induction Motors, by F. Q. Brown; Wave Frequency Meter, by G. F. LeFeure; Circuit Diagrams, by J. Millard; Little Water Passes Eagle Pass, by E. C. McMillan; S. S. Manhattan, by C. B. Sims; Communication at National Convention, by P. M. Vannoy; Constant Current Street Light Circuit, by L. P. Lovett, all students. Oct. 17. Att. 26.

Testing Surge Generators, by R. Caddock; Biography of Charles P. Steinmetz, by G. Henderson; W. Va. University Heating Plant, by R. R. McCue; Pearl Street Generating

Plant, by E. J. Williams; Public Address System, by W. D. Hall; Modern Lighting in Interurban Cars, by L. H. Winger, all students. Oct. 24. Att. 24.

Description of an Alexandrean Alternator, by N. I. Hall; 75-Kv Submarine Cable for Deepwater Station, by J. E. Wallace; Power Eliminators, by M. B. Tolley; Diesel Power Stations, by R. Marshall; Hydrogen as a Cooling Medium for Electrical Machinery, by R. H. Colborn; Turbine Design Here and in Great Britain, by L. W. Hall; Methods of Controlling the Speed of Induction Motors, by W. C. Monteith, Jr., all students. Oct. 31. Att. 25.

### University of Wisconsin

Moving pictures. Oct. 19. Att. 28.

# Employment Notes

## Of the Engineering Societies Employment Service

## Men Available

### Construction

ELEC. CONSTRUCTION ENGR with 10 yr practical experience in elec. construction on new and old buildings, including estimating, field engg. and designing. Have had complete charge of elec. construction on many buildings in New York City and can furnish the best of references. Available at once. A-[illegible]50.

CONST. MAIN. ENGR, 36, married, factory layout installation, inventive, new ideas pertaining to elec. and steam mach. conveyors, switchboard design. Power plant layout and installation, const. transmission, also good in marine work. Location anywhere. D-1622.

E.E. GRAD., Ohio State, 1929, married, 29. Three yr communication training with Ohio Bell Tel. Co., including outside line and cable construction, subway, pole line, maintenance, installation and testing experience. Not afraid of hard work. References furnished. Available immediately and will go anywhere. D-1674.

GRAD. E.E., 29, five yr supervisory construction, design, estimating and field engg experience on super-power plants and substations; 4 yr industrial power plant operation. Elec. construction and maintenance experience; railway electrification construction experience. C-4428.

### Design and Development

DISTRIBUTION, DESIGN OR MANUFACTURING ENGR, E.E. grad. 27, married. Six yr experience with Westinghouse on distribution, special and small transformer designs. Desires responsible position as transformer design, development or mfg. engr or e.e. for mfr., utility, holding company or where knowledge of big company's methods may be used. Available immediately. D-963.

E.E., univ. grad., elec. power experience, both design work and construction and maintenance work, desires position with power or mfg. organization offering permanent or temporary position in office or field. B-1923.

E.E., univ. grad., 34, single, 7 yr experience in drafting design, installation distribution networks, power companies and industrial plants. Five yr with communication engg in design, manufacture of testing equipment. Good mathematician, good draftsman. French, German, Spanish. Desires responsible position. Anywhere. D-1514.

E.E. GRAD., 33, 10 yr experience in the elec. industry, 8 yr actual experience on the design of motors and fans. Capable of assuming full responsibility for development of a-c and d-c motors and generators. Highest references. Middlewest preferred. C-5353.

ELEC.-MECH. ENGR with metallurgical knowledge. College grad. with post grad. study. Age 30, married. Westinghouse design training. Six yr experience design elec. circuits and mech. details of control apparatus, specialized in elevator equipment. Interested in alloy welding research. Location immaterial. Available on short notice. C-9638.

ELEC. AUTOMOTIVE ENGR, desires position with medium size manufacturer on design and development of automotive accessories. Have patented 19 automotive accessories. Ten yr experience and at present experimental and automotive engr on fleet of 2,300 trucks, etc. Technical education. age 32. Location New York or Philadelphia. D-1653.

E.E., 34, 10 yr experience covering design, cost estimating, and equipment specifications of power plants, industrial buildings, copper and oil refineries, substations and transmission lines. Also one yr as assist. research engr with cable co., and one yr as elec. tester with elevator co. Speak German. C-5473.

ELEC. DESIGN ENGR, 31, single, 8 yr experience in design and analyzation of manual and automatic telephone circuits. Experience on relay and switch controlled circuits for signaling or alarms. Available at once. D-1647.

E.E. GRAD., 27, single, desires position in design, development or teaching. One yr testing d-c machinery and controls, 4 yr development of outside plant hardware for telephone use. Available at once. Salary and location open. D-1305.

E.E. GRAD. of Purdue, 18 yr experience in railway, power plant, substations, transmission line, steel mill and paper mill design, construction and operation. G. E. test. Valuation, appraisal, invention. Two yr sales. Available now. Location immaterial. C-8256.

ELEC. DESIGNER, 32, married, equivalent of a college education, best of references, 14 yr experience in design of hydroelectric and steam power plants, automatic railway, high and low tension substations and low tension network systems. Available at once. Location immaterial. B-8628.

### Executives

INDUS. CONTROL AND SWITCHGEAR ENGR, Cornell graduate, married. Practical technical experience of 15 yr estimating, design, building, installation and operating of manual and automatic control applied to productive and central station industries. D-1273.

AVAILABLE AT PRESENT e.e. grad. 1920. Twelve yr. Bell System experience, 2 months' G.E. test. Married, 2 children. D-1617.

E.E., grad., 33, single, 9 yr experience. G. E. test and switchboard engg. Is thoroughly familiar with relay, meter and power circuits together with a broad knowledge of power plant and industrial elec. requirements. Can locate anywhere. B-8365-4018-Chicago.

E.E. GRAD., 37, married, with 15 yr experience covering Westinghouse test and public utility operation, finance and valuation. Familiar with elec., gas, and water properties. Prefer executive position with public utility. Location immaterial. D-1639.

ELEC.-MECH. ENGR; univ. grad., married, 34; 4 yr steel mills, one yr G. E. test, 3 yr public utility, 4 yr industrials. Estimates, designs, specifications, developments, tests, construction, supervision. Steam hydraulic power plants, manual automatic substations, converter stations, industrial buildings, overhead underground transmission systems, high low voltage equipment. Available immediately. C-2907.

ASST. ENGR, 14 yr experience, 34, married. Nine yr with 2 large eastern utilities, full engg charge in the installation and maintenance of substations and generating stations. Five yr with leading mfgr., design, development and production engg, outdoor substations and substation and transmission switching and protective equipments. D-1644.

B.S. in E.E., 26, single. Three yr general engg experience, including erecting and testing power equipment; conducting illumination and voltage surveys. Peculiarly fitted for e.e. service in Spanish speaking countries; can speak Spanish and English equally well. D-1462.

GRAD. ENGR, age 31. Ten yr experience in public utility and industrial field. Most of time on standardization, valuation and other problems of public utility economics including future expansion and budgetary control. Am conscientious worker and will make good man for some utility wishing to study changing economic conditions. B-6934.

ELEC. ENGR, married, E.E., M.E. [illegible]2 yr experience, designing, construction power plants, substations, transmission, distribution systems, and industrial plants. Three yr charge purchasing engineering equipment, foreign interests. Three yr executive experience charge engineering department large utility syndicate. English, German, Russian, Armenian, Turkish languages. Available immediately. [illegible]

GRAD. E.E., B.Sc., Master Bus. Adm., studies toward M.Sc., 36, single; 15 yr broad experience; power plant, substation design and wiring diagrams; appraisals; automatic telephone equipt., cable inspection and specs.; test work on motors and gens.; instructor elec. lab. Desires position of responsibility with industrial concern, utility, consulting engr or teaching. B-7877.

### Inspection

ELEC. GRAD., 38, single, 6 yr experience factory testing, W.E. & M. Co., East Pittsburgh, Pa. One yr steel company installing and testing elec. equipment. 6 months' factory inspection of transformers. 2 1/2 yr general inspection of elec. equipment with insurance co. Good reference. Available immediately. Any location. D-1461.

### Instruction

GRAD. E.E., 7 yr teaching, 18 yr practical experience. The last 12 yr has been along mechanical lines; steam, gas, air and water engineering, [illegible] and alkali plants, handling, conveying, and process equipment. Taught heat power engineering at Oregon State College and elec. lab at Beaune, France. Location immaterial. A-3651.

GRAD. E.E., and M.S. in Physics, 30, married. Three yr teaching physics in univ. Five yr research, high voltage insulation studies; ferromagnetic alloys; a-c, d-c, high frequency measurements; high vacuum technique; X-ray analysis. Publications. At present grad. asst. in physics. Desires teaching physics or e.e. engg or research position. Available Jan. 1. D-1616.

## ENGINEERING SOCIETIES EMPLOYMENT SERVICE

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MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco: An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

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ASSOC. OR ASST. PROF. OF E.E., age 34, B.S. in E.E. and M.S. in E.E. degrees. Five yr teaching experience leading tech. school, 3 yr as asst. prof. Four yr in charge of education and training for national technical corp. Any location. C-8967.

**Junior Engineers**

M.S. in E.E. 1932, Univ. of Pa., 23, single, desires position affording e.e. experience. Salary secondary. Go anywhere. Available immediately. D-1601.

GRAD. E.E. 1929, M.S. in E.E. 1932; 18 months' test experience at G. E. Co. with all types of elec. machinery, also some research experience. Desires engg opportunity. Salary and location secondary. Available immediately. C-9003.

E.E. GRAD., 1932; Rensselaer P. I., Sigma Xi: 22; single. Desires work in any elec. field. Salary and location immaterial. Available at once. D-1296.

I.E.E. GRAD., Pratt Institute, 1932, 20, single. Specialized illumination. Completed Westinghouse illumination course. Capable and not afraid of hard work. Excellent references. Desires any kind of work in elec. field. Location immaterial. Available immediately. D-1594.

1932 GRAD. E.E., B.S., from So. Dakota Univ., 22, single and in excellent physical condition. Best of character standing and willing to work hard, starting at the bottom and working up. Desires any position that will pay living wage. Location immaterial and available immediately. D-1635-4393-Chicago.

E.E. GRAD., B.S. Carnegie Inst. of Tech. 1932. A.B. in mathematics Oberlin College 19[illegible]. Age 24, single, member of Eta Kappa Nu. Location and salary immaterial. Want to gain experience. Available at once. D-1640.

RECENT CORNELL GRAD., 23, single, holding B.S. in E.E. and M.S. deg.; desires connection with opportunity for a future responsible technical position. Excellent scholastic and personal records. A little factory experience. D-1621.

B.S. in E.E. 1931, Mich. Col. of Min. & Tech., single, 23, Tau Beta Pi. Desires work in any engg field. Experience: 3 months' swbd. wiring, 1 month lighting design, 6 months' surveying and map drawing. Speaks Finnish. Location in northern half of U.S. preferred. Available at once. D-1650.

YOUNG ENGR, 25, single. Brooklyn Poly. Inst. evening student, 1927 to date. Five yr varied experience, steam and elec RR construction, secretarial. Well versed in mathematics. Desires position in any engg field. Available immediately; location, New York City. C-8672.

B.S. in E.E. 1927. Married, 28. Five yr experience in telephone work. Desire engg work of any nature or position in law department of mfg. concern. Available immediately. D-1673.

E.E. GRAD., M.I.T., S.B., 1931, S.M. 1932, 2[illegible] single. 16 months' experience with Edison Electric Illuminating Co. of Boston as a cooperative student. Desires position in power transmission field, but is interested in any position with a reasonable chance for advancement. Location immaterial. References. D-1685.

GRAD. E.E., 1929, single, 24. Fifteen months' student engr on G. E. test. Some test, drafting and switchboard construction experience before graduation. Interested in position with concern doing consulting, or construction work or with utility or mfr. Available at once. Location anywhere in U.S., but New England preferred. C-8028.

B.S. in E.E. recent, 4 yr radio experience. Desires any position, moderate salary. Age, 22 years. D-1488.

B.S. in E.E., 1932, single, 21. Gained experience in elec. instrument plant during cooperative course. Desires any position for experience. Salary secondary. D-1578.

**Maintenance and Operation**

PRACTICAL ELEC. CONST. AND MAINT. CHIEF, age 32, single, 14 yr experience in construction work, also maintenance and operation of mines and industrial plants. Last 4 yr in Latin-America. Can speak Spanish and German well. Available immediately. Location, immaterial. C-2101.

ELEC. GRAD., 15 yr broad experience, factory testing, construction, substation operating and maintenance. Theoretical and practical. Desires position of responsibility. C-38.

**Research**

RESEARCH: testing and research engr: phys., tests of materials, metallography, X-ray and spectroscopic structure analysis. Well versed in physics. Languages: English, German, French. Location and salary of secondary importance to opportunities. C-6994.

M.S. in E.E., Johns Hopkins Univ., Univ. of Pa. fellowship holder, married, good health, analytical, 28. Two yr teaching experience, mathematics, physics, e.e., 2 yr practical, theoretical experience, long-distance telephone transmission from New York to San Francisco. Desires teaching, personnel, research along mathematical-physical lines, or invites correspondence. Excellent references. D-1609.

E.E., 28, married, has 3½ yr experience in lab., testing and research work, desires position, preferably with small concern anywhere in U.S. D-1657.

RESEARCH AND DEVMT. ENGR, B.S. and M.S. in E.E. Two yr additional grad. work in physics. Single, 28. Five yr with Westinghouse. Experimental work dealt with arc rupture, control apparatus, and the use of X-rays to study molecular structure. Location and salary secondary to position, with opportunity for future. D-1331.

HYDROLOGICAL & METEOROLOGICAL RESEARCH ENGR, B.S., M.S. & E.E., 7 yr hydroelec. experience in large public utility engg dept., 3 yr studying climate cycles, ground waters and storage reservoirs, forecasting precipitation runoff and storage, testing flow lines, penstocks and turbines, making stream measurements and snow surveys. Location U.S. or foreign. C-6853.

E.E. GRAD., Penn State, 1932, Honors, 22, single. Some experience in shortwave receivers. Desires research work in short-wave, ultra short-wave, photo electric cells, vacuum tubes, etc., also radio communication at sea. Either foreign or domestic field. Salary secondary. Available now. D-1513.

Sc.D. in E.E. M.I.T. '32; 7 yr Univ. education; 9 yr pract. exp., power, communication and business engg; 2 yr testing course; publications. Extensive knowledge of languages; available. Location immaterial. D-747.

**Sales**

SALES ENGR, 30, single, E.E. grad. of a reputable, one yr engg school. Five yr experience selling industrial and central station instruments. Desires position as salesman with a high grade mfg. concern. No particular line desired. Will travel, location immaterial. C-1570.

**Testing**

ELEC. INSPECTOR OR TEST MAN, 29, single, 8 yr experience with power and manufacturing companies. Also experience with automatic telephone equipment and communication. Knowledge of theory as well as practise. Can furnish best of references. Location immaterial. Available at once. D-1618.

# Membership

## Recommended for Transfer

The board of examiners, at its meeting of November 9, 1932, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the acting national secretary.

**To Grade of Fellow**

Lyon, Waldo V., prof. of elec. machinery, Mass. Inst. of Tech., Cambridge, Mass.
Merwin, Louis T., vice-pres., and gen. mgr., Northwestern Elec. Co., Portland, Ore.
Sabbah, Hassan Camil Ali, elec. engr., Gen. Elec. Co., Schenectady, N. Y.
Sheehan, John E., chief engr., Houston Lighting & Power Co., Houston, Texas.

**To Grade of Member**

Adler, Wm. M., asst. to distribution engr., Bronx Gas & Elec. Co., Bronx, N. Y.
Beckman, Joseph S., engr. of plant extension, Bell Tel. Co. of Pa., Philadelphia, Pa.
Bricker, L. B., division maintenance supervisor, Southwestern Bell Tel. Co., Houston, Texas.
Bureau, E. A., prof. of elec. engg., Univ. of Kentucky, Lexington, Ky.
Burrows, C. R., radio research engr., Bell Tel. Labs., Inc., Deal, N. J.
Cannon, Robert S., pwr. plant foreman and elec. engr., Lago Petroleum Corp., Venezuela, S. A.
Gould, Leroy B., inductive relations engr., New England Tel. & Tel. Co., Boston, Mass.
Howarth, Oliver, technical engr. and meter supt., Lancashire Elec. Pwr. Co., Manchester, Eng.
Joh[illegible], Royce E., director, elec. stds. lab. and instructor in elec. engg., Univ. of Wisconsin, Madison, Wis.
Lidbury, Frank A., pres. and gen. mgr., Oldbury Electro-Chemical Co., Niagara Falls, N. Y.
Mueller, Walter E., patent solicitor, Denison & Thompson, Syracuse, N. Y.
Ortlieb, Otto P., engr. of street lighting, City of Trenton, Trenton, N. J.
Pokorny, Jerome J., elec. engr., Cleveland Elec. Ill. Co., Cleveland, Ohio.

## Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the acting national secretary before Dec. 30, 1932.

Adams, E. F., 839 Monroe Ave., Elizabeth, N. J.
Anderson, I. Jr., 108 Burncoat St., Worcester, Mass.
Barbee, G. C., Southwestern Bell Tel. Co., St. Louis, Mo.
Barnett, H. G., Ore. State Col. Corvallis, Oregon.
Beale, F. S., 1802 Cleveland Blvd., Caldwell Idaho.
Beard, W. G., Rippowam, Ridgefield, Conn.
Beckert, J. E., 27 Clarendon Place, Buffalo, N. Y.
Bell, J. S., Mass. Inst. of Tech., Cambridge, Mass.
Brainard, W. E., 12222 Taft Ave., Cleveland, Ohio.
Briansky, D., 6730 13th Ave., Brooklyn, N. Y.
Brigham, E. R., 1503 Superior St., Toledo, Ohio.
Brown, J. D., Hatfield Wire & Cable Co., Hillside, N. J.
Bruggink, C. P., 309 10th St., Hoboken, N. J.
Burmiester, H., Safe Harbor Water Power Corp., Safe Harbor, Pa.
Calkins, D. S., Henrietta, N. Y.
Carlson, R. W., No. Dak. R. R. Commission, Bismarck, N. D.
Carson, H. E., New England Power Engg & Service Corp., Worcester, Mass.
Colegrove, W. D., Remus, Mich.
Collins, J. E., National District Telegraph Co., New York, N. Y.
Crawford, E. J., Oyama, B. C., Canada.
Deck, H. A., Gen. Elec. X-Ray Corp., Dallas, Texas.
Devine, B. A., City & County of San Francisco, Calif.
Frey, G. O., Warner Bros. Theatres, Inc., New York, N. Y.
Gammons, J. M., Southwestern Bell Tel. Co., St. Louis, Mo.
Gegely[illegible], C., United Electric Lt. & Pwr. Co., New York, N. Y.
Gerlach, W. G., Gen. Elec. Co., Toledo, Ohio.
Gustafson, W. G., Bell Tel. Labs., Inc., New York, N. Y.
Hagood, G. B., Jr., Winnsboro, S. C.
Hanson, J. W. (Member), Columbia Engg. & Mgt. Corp., Cincinnati, Ohio.
Harvey, G. C., Gibbs & Hill, Inc., Rahway, N. J.
Hatfield, L. N., KWSC, State Col. of Wash., Pullman, Wash.
Haward, R., The Saskatchewan Pwr. Commission, Regina, Saskatchewan, Can.
Hawley, E. F., Ormstown, P. Q., Canada.
Heidenreich, E. C., Dental & Medical Elec. Equipment, Buffalo, N. Y.
Hope, H. W., 338 Harvard St., Cambridge, Mass.
Howell, W. J., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Hudgins, W. D., 1422 Arch St., Berkeley, Calif.
Hutchinson, M. C., 316 West 14th St., New York, N. Y.
Johnson, H. W., 31 Washington St., East Orange, N. J.
Johnson, V. T., 3610 Bellevue Ave., Los Angeles, Calif.
Juc[illegible]arone, N. T., Otis Elevator Co., Yonkers, N. Y.
Kahlbaum, M. E., Kahlbaum Brothers, Carleton, Mich.
Kastens, R. H. C., 105 Hauxhurst Ave., Weehawken, N. J.
Kelsay, W. D., 401 Martinique St., Dallas, Texas.
Kowalewski, H. M., B. F. Sturtevant Co., Boston, Mass.
Kuhlman, P. W., 509 Smith Ave., Detroit, Mich.
Laine, M. W., 546—40th St., Brooklyn, N. Y.
Libby, C. C., University of Cincinnati, Cinc., Ohio.

Lindsay, V. H., B. F. Sturtevant Co., Hyde Park, Mass.
Lindsley, R. P. Jr., So. Methodist Univ., Dallas, Texas.
Lockie, A. McL., Rensselaer Polytechnic Inst., Troy, N. Y.
Mahalak, A. F., Michigan Alkali Co., Wyandotte, Mich.
Malone, C., Jr., Monongahela West Penn Public Service Co., Fairmont, W. Va.
Martinson, E. O., Box 5, Harrah, Wash.
McCracken, G. I., 152[illegible] Termon Ave., N. S., Pittsburgh, Pa.
McFarlin, V. S., 922 Beacon St., Boston, Mass.
McNarney, H. J., 158 West Maple St., Wabash, Indiana.
Miller, H. W. R., New York Tel. Co., New York, N. Y.
Miller, W. H., 1956 North High St., Columbus, O.
Mitchell, F. H., Mitchell Radioservice Co., Mobile, Ala.
Morgan, J. M., 737 Ridgway Ave., Morgantown, W. Va.
Morton, P. L., Firland, Richmond Highlands, Wash.
Mowat, D., Saskatchewan Power Commission, Regina, Saskatchewan, Can.
Munroe, J. P., 120 Hobart St., Ridgefield Park. N. J.
Osgood, V. L. (Member), Hardwick-Hindle, Inc., Newark, N. J.
Parsons, C. B., 1261 Atlantic St., Portland, Oregon.
Pashek, R. J., 1969—25th St., Detroit, Michigan.
Rahlke, H. W., P. O. Box 199, Salem, Ohio.
Ranson, L. R., Gen. Elec. Co., Schenectady, N. Y.
Reizenstein, M., Jr., 2134 Brookfield Ave., Baltimore, Md.
Riedy, K. F. R., Route No. 4, Allentown, Pa.
Roberts, F. F., R. F. D. No. 2, Parma, Idaho.
Rogers, A. G., Clio, Mich.
Roswell, E. R., P. O. Box 203, Devon, Conn.
Scrutchin, C. G., 227 Hancock St., Decatur, Ga.
Sechler, F. E., Great Western Sugar Co., Ovid, Colo.
Sann, J. W., Southern Bell Tel. & Tel. Co., Louisville, Ky.
Stanton, S. W., United Electric Lt. & Pwr. Co., New York, N. Y.
Sterling, O. R., Hop Bottom, Pa.
Stewart, H. M., Humble Oil & Refining Co., Baytown, Texas.
Stieg, H. R., 157 Monroe St., Hartford, Conn.
Tankovich, J. G., 497 East 11th Ave., Columbus, Ohio.
Thomas, R. G., Carolina Pwr. & Lt. Co., Raleigh, N. C.
Walsh, W. C., Rt. No. 2, Box 379, Gilroy, Calif.
Wanger, L. R., Phila. Elec. Co., Philadelphia, Pa.
Wiedenheft, A. H., Good Thunder, Minn.
Willson, W. H., Jr., Randall, Iowa.
Wells, M. F., 261 Hartford Ave., Wethersfield, Conn.
West, C. V., 2001 Barton Ave., Richmond, Va.
Weston, F. B., Sage Allen & Co., Inc., Hartford, Conn.
Womack, S. H. J., Bureau of Standards, Washington, D. C.
Woodruff, R. T., 232 E. Broadway, Girard, Ohio.
Woodward, M. W., Cheyenne Wells, Colorado.
Young, C. E., Johns Hopkins Univ., Baltimore, Md.
Zeitz, A., 264 Berriman St., Brooklyn, N. Y.
95 Domestic

### Foreign

Lautier, V., 37 Sda. San Paolo, Cospicua, Malta.
Lindorf, L. S., Bol. Kommunisticheskaia 7 Kv. 1 Moscow 4, U.S.S.R.
Lloyd, H. S., Metropolitan-Vickers Elec. Co. Ltd., Traford Park, Manchester, England.
Sarda, P. M., Ratan Pole, Nagori Pole, Ahmedabad, India.
Singh, H., Simla Municipal Committee, Idgah, Simla, India.
Swami, T. V., Elec. Dept., Cocanada, India.
Tharani, J. J., Elec. Pwr. House, Veraval, Kathiawar, Manavadar, India.
7 Foreign

# Engineering Literature

Unless otherwise specified, books in this list have been presented by the publishers. The society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

BERECHNUNG von GLEICHSTROM-KRAFTÜBERTRAGUNGEN. By O. Burger. Berlin, Julius Springer, 1932. 82 p., illus., 9x6 in., paper, 6.40 rm.—A practical discussion of the calculation of long-distance a-c transmission lines, in which attention is paid to economic and electrical factors. Various methods of transmission are compared.

COMPANY PLANS FOR UNEMPLOYMENT RESERVES. Washington, D. C., Chamber of Commerce of the U.S., Dept. of Manufacture, 1932. 42 p., tables, 9x6 in., paper, gratis.—To assist employers who desire to devise means for protecting their staffs from unemployment. Purpose and advantages of company reserve plans, coverage and experience of existing plans, procedures for establishing plans, and development of uniform plans by industries or communities, are discussed.

ELECTRIC AND MAGNETIC FIELDS. By S. S. Attwood. N. Y., John Wiley & Sons, 1932. 314 p., illus., 9x6 in., cloth, $3.50.—Represents a course given to students of E.E. at the Univ. of Mich., to coordinate the under-class work in mathematics, mechanics and physics with professional work of the last 2 years. The book is in 4 parts: electric field; magnetic field; ferromagnetic field; and combined electric and magnetic fields.

ELECTRONS AND WAVES. By H. S. Allen. Lond. & N. Y., Macmillan Co., 1932. 33[illegible] p., illus., 8x5 in., cloth, $2.50. Consists of lectures dealing with recent progress in our knowledge of the constitution of matter and the nature of radiation. Intended for readers who have not specialized in physics, but who wish something more than an entirely elementary account of the subject. Such topics as relativity, the quantum theory, radioactivity and wave mechanics are presented in this concise outline.

ELEKTRISCHE GASENTLADUNGEN. Bd. 1. By A. v. Engel and M. Steenbeck. Berlin, J. Springer, 1932. 248 p., illus., 10x6 in., cloth, $5.50 rm.—This treatise, which will comprise 2 volumes, aims to provide a systematic, comprehensive discussion of the discharge of electricity through gases, in which the needs of the experimenting physicist and the research engineer will be given consideration above those of the student of atomic physics. This volume develops the basic laws of discharges in gases from simple concepts, without using difficult mathematical processes and compares them with experimental results.

HANDBOOK of CHEMISTRY and PHYSICS. Edit. by C. D. Hodgman. 17 ed. Cleveland, Ohio, Chemical Rubber Pub. Co., 1932. 1,722 p., tables, 7x5 in., leather, $6.00.—This edition has undergone an extensive revision which has resulted in an addition of 150 pages of new matter. 1,000 new compounds have been added to the table of physical constants of organic compounds, which now includes over 4,000 substances, and the former data carefully corrected. The mathematical section has been enlarged by adding several useful tables; new tables have been added to all divisions of the book.

HANDBOOK of INDUSTRIAL TEMPERATURE and HUMIDITY MEASUREMENT and CONTROL. (Manual of Instrumentation.) Parts 2 and 3. By M. F. Béhar. Ed. 1. Pittsburgh, Instruments Pub. Co., 1932. 309 p., illus., 10x6 in., cloth, $4.00.—Having presented the fundamentals of industrial instrumentation in his first volume, Mr. Béhar now takes up 2 subjects, the measurement and control of temperature and of humidity. Detailed information is presented upon thermometers, pyrometers, heat recorders and controllers, and instruments for measuring and controlling humidity. Detailed descriptions of the principal instruments on the market, and general principles underlying them are presented.

Die KÜNSTLICHEN KOHLEN für elektrische Öfen, Elektrolyse und Elektrotechnik. By K. Arndt. 2 Auflage. Berlin, J. Springer, 1932, 336 p., illus., 9x6 in., leather, 38 rm.—A comprehensive account of the carbon electrode industry. After a short historical introduction, raw materials are considered, their mixing, ignition and preparation described. Chapters then follow upon chemical, physical, and microscopic testing and upon the use of carbon electrodes in furnaces and baths. Carbons for arc lamps, brushes, batteries, microphones, and other purposes are discussed. The book is a rewritten edition of Zellner's work on this subject.

REFRIGERATION, including Air Conditioning and Cooling and Household Automatic Refrigerating Machines. By J. A. Moyer and R. U. Fittz. 2 ed. New York and London, McGraw-Hill, 1932. 538 p., illus., 9x6 in., $5.00. Intended both as a textbook and reference work as a useful outline of current conditions and practise. The theory of refrigeration and the methods in use are described and explained. New features of improved designs of household and small commercial refrigerators, silica-gel systems, revised data on refrigerants, production of dry ice, applications of quick freezing, and air conditioning, are described.

REWINDING SMALL MOTORS. By D. H. Braymer and A. C. Roe. 2 ed. New York & London, McGraw-Hill, 1932. 263 p., illus., 9x6 in., cloth, $2.50. Intended as a guide to repairmen called upon to rewind portable drills, motors for automobile starters, sewing machines, vacuum cleaners, fans and other small machinery. A chapter on single-phase motors of the condenser type has been added. The directions are full and detailed and sufficient for all needs of experienced winders.

STEAM POWER PLANT ENGINEERING. By L. A. Harding. New York, John Wiley & Sons, 1932. 777 p., illus., 9x7 in., cloth, $10.00. To outline briefly in an elementary manner the major problems in the design of steam generators, engines, turbines and accessories, to show their interrelations in power plant engineering, and to discuss the economic factors involved in their selection. A large amount of practical data not readily accessible elsewhere is assembled in convenient form, making it useful for reference as well as for study.

TABLES OF CUBIC CRYSTAL STRUCTURE OF ELEMENTS AND COMPOUNDS. By I. E. Knaggs, B. Karlik and C. [illegible]. Elam. London, Adam Hilger, Ltd., 1932. 90 p., tables, 10x6 in., cloth, 11s. 6d. A useful reference book for chemists and metallurgists who use X-ray methods for the analysis of powders and crystals. One section upon inorganic and organic substances; and another upon alloys. Each section gives table listing the substances: alphabetically, and systematically by the side length of the unit cube cell. The bibliographies contain over 900 references. An attempt to tabulate all data scattered through periodicals up to August 1931.

THERMODYNAMICS. By J. E. Emswiler. New York & London, McGraw-Hill, 1932. 347 p., 9x6 in., cloth, $3.00. The special feature of this textbook is a progression from the topics most familiar to the student to those with which he is inexperienced. Study of the steam engine comes first, followed by vapor refrigeration, permanent gas mixtures and air heat engines; finally the laws of thermodynamics and the kinetic theory of heat. Earlier edition partly rewritten and new matter added.

URBAN LAND USES, Amounts of Land Used and Needed for Various Purposes by Typical American Cities, an Aid to Scientific Zoning Practice. (Harvard City Planning Studies, v. 4.) By H. Bartholomew. Cambridge, Harvard Univ. Press, 1932. 174 p., 10x7 in., cloth, $3.50. The results of an investigation undertaken to determine the requirements of the American city as to the land areas used for various purposes, the ratios of these areas to a given population unit, and analogous statistical information of aid in scientific zoning. These data provide a method for estimating the total area required for each particular urban use for any given future population of between 5,000 and 300,000 inhabitants.

WORLD SOCIAL ECONOMIC PLANNING, the Necessity for Planned Adjustment of Productive Capacity and Standards of Living. 2 v. The Hague, Holland, Intl. Industrial Relations Inst., also Room 600, 130 East 22nd St., New York, 1932. 935 p., 10x6 in., cloth, $2.50. Containing papers and discussions presented at the Congress in Amsterdam in 1931, where the necessity for planned adjustment of productive capacity and standards of living was discussed by a group of economists and sociologists of many countries.

**Engineering Societies Library**

**29 West 39th Street, New York, N.Y.**

MAINTAINED as a public reference library of engineering and the allied sciences, this library is a cooperative activity of the national societies of civil, electrical, mechanical, and mining engineers.

Resources of the library are available also to those unable to visit it in person. Lists of references, copies or translation of articles, and similar assistance may be obtained upon written application, subject only to charges sufficient to cover the cost of the work required.

A collection of modern technical books is available to any member residing in North America at a rental rate of five cents per day per volume, plus transportation charges.

Many other services are obtainable, and an inquiry to the director of the library will bring information concerning them.

## Industrial Notes

**General Electric to Exhibit at Chicago Fair.**—The "House of Magic," a spectacular section of the G-E research laboratories, will be moved to Chicago for the 1933 World's Fair as the outstanding feature of the General Electric Company's exhibit. The exhibit will occupy 9,000 sq ft of space in the circular hall of the Electrical Building and will represent an investment of five hundred thousand dollars.

**Roller-Smith Appointments.**—Mark G. Mueller, 1700–16th St., Denver, has been appointed by The Roller-Smith Co., New York, as district sales agent for the states of Colorado, New Mexico, and the western part of Kansas. Burkholder and Kelley, 105 Cortleigh Boulevard, Toronto, have been appointed representatives for the Dominion of Canada.

**Rockbestos Moves Chicago Office.**—The Rockbestos Products Corp., New Haven, Conn., manufacturers of asbestos insulated wires and cables and flexible cords, announces a change in the location of its Chicago office and warehouse from the Madison Terminal Building to the Marquette Building, 140 So. Dearborn St., Chicago, Ill.

**L. M. Christie Promoted by National Fireproofing Corporation.**—L. M. Christie has been elected vice-president of the National Fireproofing Corporation, Pittsburgh, with which he has been connected since 1902. He will continue in charge of the sales engineering end of the conduit division. Mr. Christie has been identified with the clay conduit branch of the electrical industry almost from its inception, coming to the states from Windsor, Canada, in 1900 to enter the employ of John T. McR[illegible]. The latter was an inventor and a pioneer manufacturer of the present type of multiple duct clay conduit for housing telephone, telegraph, and electric power cable lines.

**Calculating Board in Regular Use by Utility.**—Studies of power flow, regulation, losses, power factor and system stability are made quickly and easily on the alternating-current calculating board recently installed in the engineering department of the Commonwealth Edison Company, Chicago. Built by the Westinghouse Electric & Manufacturing Company, it is said to be the first alternating-current calculating board to be placed in regular use by an operating utility. It operates on a frequency of 440 cycles. On it can be reproduced in terms of circuit constants the whole or any part of the Commonwealth Edison a-c system.

**General Electric Receives Largest Mercury Shipment.**—What is probably the largest single shipment of mercury ever made arrived in New York recently for the General Electric Company, to be used in generating power in the new 20,000-kilowatt mercury turbine just installed at the Kearny station of the Public Service Corporation of New Jersey. The shipment consisted of 270,000 pounds, and was delivered in 3553 iron flasks, each flask containing 76 pounds. The value of the mercury in the whole order is about $350,000, as this shipment represents only half of the company's needs. The remaining 270,000 pounds will be delivered later and will be used for generating power in the new mercury turbine plant being built in Schenectady. The total order represents about 89 per cent of the mercury consumed by the United States in an average year.

**Bristol Opens British Factory.**—The Bristol Co., Waterbury, Conn., announces the establishment of a British factory at London under the name of Bristol's Instrument Co., Ltd. Since 1889 the Bristol Company has had a very substantial trade with Great Britain in its line of recording instruments, its selling activities in that country being handled by J. W. & C. J. Phillips, Ltd., as sales agent. Although the general expansion program of the company contemplated the founding of a British plant at some future time, the altered economic and business situation within Great Britain made an earlier establishment for manufacturing in that country seem advisable. Howard H. Bristol, president of The Bristol Company, recently made a special trip to London to investigate the situation, and during his visit laid the plans and arranged for the formation of the British company. The new plant, located at 144 Pomeroy St., New Cross, London, consists of an office building and a two-story factory building of modern construction, and is prepared to manufacture and service the complete line of the company's indicating, recording and controlling instruments.

**A New Testing Device.**—Ferranti, Inc., New York, has introduced a complete testing kit comprised of the dual range clip-on ammeter, which met with widespread acceptance a few months ago, and a three range portable voltmeter. The clip-on ammeter has two scales, 0/100 and 0/500 amperes, and reads accurately currents ranging from 10 to [illegible] amperes without the necessity of breaking the circuit or the use of split-core current transformers. The instrument is simply clipped over the conductor and the current is read off directly. It can be operated with one hand, and is suitable for use either on the ground or up a pole. The second instrument in the set, the triple range portable voltmeter, has full scales of 150, 300, and 600 volts which take care of the standard distribution voltages of 110, 220, 440, and 550. This meter, although of the moving iron type, has a comparatively high resistance, making its readings extremely accurate. It is suitable for use on either direct or alternating current and is independent of frequency between 25 and 100 cycles.

The two instruments in this set are accurate and convenient, and although of a precision nature, they are robust in construction. They are supplied in a solid leather case equipped with lock and key, in addition to hand and shoulder carrying straps. The set is particularly adapted for determining the actual voltage and loading on transformers, motors, etc., for balancing secondary transformer loads on three-wire services, or for checking power consumers' loads and voltages. It may also be used to check single or three-phase kva.

## Trade Literature

**Arc Welders.**—Bulletin HW-2, 20 pp. Describes the improved line of P & H Hansen arc welders, designed by K. L. Hansen. Harnischfeger Corp., Milwaukee.

**Condensers.**—Catalog, 16 pp. Included in this complete line are a series of oil impregnated, oil filled paper condensers especially adapted for use with capacitor motors, power factor correction and other industrial applications. Electrolytic, paper and mica condensers are also described. Dubilier Condenser Corp., 4377 Bronx Blvd., New York.

**Wire Rope Slings.**—Catalog, 86 pp. Includes the latest available information on various types of slings now being used in shop and field for the handling of all kinds of loads. Numerous illustrations show the application of these slings in handling heavy apparatus and castings. John A. Roebling's Sons Co., Trenton, N. J.

**Square Case Instruments.**—Bulletin L 20545, 8 pp. Describes a new line of switchboard square-case instruments, including ammeters, milliameters, voltmeters, milli-voltmeters, single and polyphase power factor meters, frequency meters, and synchroscopes. Both a-c and d-c instruments are intended for service on large switchboards of steel, ebony asbestos, or slate. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

**Zinc for Die Castings.**—Bulletin 20 pp. Illustrates a multiplicity of uses for zinc die castings. Charts and table on the effect of aging treatments on tensile strength, impact strength, and dimensions of the "Zamak" alloys are published for the first time. Heat treatment for stabilizing the dimensions and properties of a zinc die casting alloy is also discussed. New Jersey Zinc Co., 160 Front St., New York.

**Metal-Clad Switchgear.**—Bulletin GEA 1661, 12 pp. Describes type MI-6, latest G-E metal-clad switchgear, for a wide range of applications—central station main and auxiliary circuits, industrial plants, etc. The principal improvement of many in this apparatus is the use of oil-blast circuit breakers having interrupting ratings from 50,000 to 500,000 kva, 15,000 volts and up to 2,000 amperes. Each unit consists of a complete self-contained switching equipment with a stationary and removable element. General Electric Co., Schenectady, N. Y.